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For the Journal of the Franklin Institute.

Shot-Proof Vessels—Ericsson's Battery. By ISAAC NEWTON, First Assistant Engineer, U. S. N.

AT the present time, while the government is working at the problem of iron-clad vessels, and all thinking citizens are deeply interested and anxiously awaiting the result, an impartial discussion of this very important subject, would not be out of place. It is a matter, too, of the greatest importance financially, as it involves the expenditure of many millions of dollars.

We have delayed too long the construction of iron-clad shot-proof vessels, but before we commence to build them in large numbers, a thorough investigation of the subject is absolutely necessary. Even this delay may, however, prove to be a great advantage, as it gives us the experience of both France and England in building them, as well as the knowledge eliminated by the voluminous papers written by professional men, and published in the principal magazines of England, and also of the discussions, both for and against, between many of her prominent engineers, army and navy officers.

Many of these articles, and also several scientific men, have declared in the most emphatic manner that it would be an act of utter folly to place another wooden war vessel on the stocks, or even to complete those already commenced.

Sir Howard Douglas, one of the first authorities on naval and military matters, and to whom the British navy is greatly indebted for its

present efficiency, has most strenuously opposed all such radical changes. The arguments, facts, and statistics brought to bear by Sir Howard against the use of iron vessels for war purposes, it would be well for every unprejudiced person to examine before forming a hasty conclusion.* In these remarks, Sir Howard does not refer particularly to iron-clad vessels, and his criticisms on that class of vessels are principally as to their efficiency as *cruisers to take place of wooden ships.* Sir Howard revised the last edition of his Naval Gunnery in his *eighty-fifth* year. This venerable and conscientious man has been, on this account, assailed on every side by a host of writers, who, whatever else may have been their ability, had not that thorough scientific knowledge which was necessary to combat the array of facts and arguments he displayed.

The project of clothing vessels with iron armor for the purpose of resisting shot, is not of as recent a date as is generally supposed; it was suggested by Col. Paixhans, better known as the inventor of the Paixhans shell gun, nearly forty years ago. The first examples we have, however, of iron-clad vessels, were those constructed in France and copied by England in the late war with Russia. They were used in conjunction with the immense allied fleet at the attack on Kinburn, and the result, as far as these batteries were concerned, cannot be regarded as settling much in their favor. Douglas states them to have been utter failures; at any rate, they could not carry their own armament, and all their guns were conveyed in transports employed for the purpose.*

The two types of iron-clad vessels upon which we have been accustomed to look, are the French *Gloire* and the English *Warrior.*

These ships differ essentially in many points, but they both possess defects inherent to their mode of construction, which impair their efficiency, either as cruisers or floating batteries, and the idea that such vessels are to take the place, or to perform the duties required of the old-fashioned wooden war vessels, is not for a moment to be tolerated. It is proposed to show, that the principles adopted in the construction of both these vessels are erroneous, and that for the amount of money the *Warrior* cost, eight or nine iron-clad steamers, perfectly impregnable to any projectile she can throw at the shortest ranges, could be constructed, and each one capable of coping with this vaunted frigate. Vessels of the usual form plated with impenetrable armor, will not fulfil either the conditions required of men-of-war, or of impregnable ships. Both the *Gloire* and the *Warrior* may be of special service against a neighboring belligerent power, but not as cruisers, nor as antagonists which we need fear.

Iron-plated shot-proof vessels have their especial function to perform; they can never be any thing more than auxiliaries to a navy and adjuncts to forts for the defence of our harbors, bays, and coasts.

Let us examine the two mail-clad vessels mentioned. The *Gloire* was the first completed. The project, it appears, had long been a favorite one with Napoleon III. She is so overloaded with the enormous weight of her armor, 850 tons, and her armament, that in any thing like a

* Vide Naval Gunnery, and Postscript, by Gen. Sir Howard Douglas, London.

heavy sea, the water not only comes up into her ports, which are but six feet from the surface of the water, but rolls up her sides and over her. Her centre of gravity is so near the metacentre, from the fact that the immense weight of her armor above the water line brings it so much higher above the centre of gravity of the water displaced compared with ordinary vessels, that she is very deficient in stability, and consequently she rolls very deeply; besides, she has no great speed; when loaded for sea and in smooth water, it will probably not be over nine knots.

As a sea-going ship, she is, therefore, an utter failure. The only duty she can perform, and that indifferently, is that of a floating battery.

It may be said, these defects can be obviated in future. In the *Warrior*, in endeavoring to correct these, new ones were created.

Nature will not change her laws: to be successful in mechanics, they must be obeyed.

The English naval architects appreciated these difficulties, and tried to correct them as much as possible, as will be seen by the plans adopted in the construction of the *Warrior*.

This vessel differs from her rival in several important points.

1st. She is constructed entirely of iron, whereas the *Gloire* is a wooden ship iron plated.

2d. Only the central portion of the ship is covered with armor; each end, for a length of nearly one hundred feet, is built in the same manner as is usual with ordinary iron steam ships, the sides being made of plate-iron five-eighths of an inch thick.

3d. Her tonnage is very much greater than that of the *Gloire*.

The reasons for these important differences are obvious. As one of her admirers has well stated, speed had to be attained in combination with a shot-proof hull, and had not the proposal to leave the ends of the ship uncased been adopted, this combination would have been practically impossible, except with far greater dimensions than even the *Warrior's*.

Her constructors, as has been remarked, appreciated at once the defects of the *Gloire*, and endeavored to obviate, or at least to ameliorate them as much as was possible, in the construction of the *Warrior*. They were determined at any rate to build a ship which would perform more satisfactorily at sea; and they were required to excel their rival in speed. The *Gloire* was deficient in stability; she would be a mere log in a sea way; her guns were but six feet from the water, and could not be used at all, except in comparatively calm weather. Therefore, to overcome these difficulties, they build a larger ship, and to make assurance doubly sure (as regards sea qualities and speed), they only cover seven-thirteenths of her length with armor. Even the increased size alone was a very great advantage in assisting them to accomplish these ends. This is apparent when it is remembered that the area to be covered by iron armor increases as the square, while the capacity to carry it, or, in other words, the displacement of the vessel, increases as the cube of the dimensions.

The part protected by shot-proof armor does not, in this ship, much exceed the length occupied by engines and boilers.

Again, her ends being free from the enormous weight of shot-proof armor, they were enabled to make them much finer than otherwise; and almost for the first time in the construction of a war vessel, the armament was the last thing considered; it was ship first, and *battery* last.

She is, according to the published statements, a forty-eight gun ship, of which but thirty-six are *protected* by shot-proof armor.—These guns are the 68-pounder of ninety-five hundredweight; it has been stated, however, that some of these may give place to 100-pounder Armstrong rifled guns.

It has been perceived that both extremities of the *Warrior* are exposed to destruction; that only the central part is pretended to be shot-proof. The masts, sails, and rigging, are liable to be shot away, and strew the decks, to drag over the sides and entangle the screw, preventing it from being used. The bow, together with the rigging it supports, and the stern, which not only contains the officers' quarters, but also supports those vital parts, the *screw* and *rudder*, will be exposed to destruction by the enemy's shot, and most certainly they will be the parts aimed at.

Although when both her extremities are shattered and filled with water, she may not sink, her situation at sea would be one of extreme danger, or if attacking a fortification, equivalent to a capture. That the mistake of leaving these ends unprotected is acknowledged, every candid person will admit, when it is stated that the iron-clad vessels now being built in England, are to be plated from stem to stern, the beautiful overhanging prow and the round ornamental stern, which we have all considered as essential features of a man-of-war, are abandoned; they begin to understand now the defects of the *Warrior* as well as they did those of the *Gloire*, and appreciate thoroughly the inefficiency of the enormous and extravagant vessel just completed. In the new vessels, the bow and stern will be nearly alike; experience has taught them the difficulty, if not the almost impossibility of plating vessels of the ordinary form with shot-proof armor from stem to stern; they are driven by necessity to a more simple shape. Still, they are producing vessels which are comparatively useless for many of the purposes intended, as from their great draft of water, there are few harbors which they can enter with safety. The immense weight of their armor, owing to the large amount of *surface* to be protected, is utterly incompatible with speed, and even their batteries are not so *very* formidable.

There is every reason to believe that even the *Warrior* herself, with her fine uncased ends, can never at sea under steam, attain a speed of over eleven knots. It must be borne in mind, when reading of the performances of steam vessels, that the speed usually credited to them, is that which they have on a trial trip attained in some smooth harbor for a measured mile, under circumstances which are seldom met with at sea, and when their boilers are new and perfectly clean.

Now what function can these colossal and expensive structures perform? Can they demolish our granite casemated forts, enter our harbors, and shell our cities, even if a fleet of them should succeed in crossing the Atlantic? No, they cannot; from their great draft of water they cannot succeed in approaching within breaching range of most of our forts, and even if the object to be attained should not be to reduce but to run by them for ulterior purposes, they can be stopped, yes, destroyed, if the attempt should be made; provided we use the means in our power; that is, if the forts are provided, as the U. S. Engineers insist, with the heaviest *successful* ordnance known, the fifteen-inch gun, cast after the method of Capt. Rodman, U. S. A.,* a shot from which would literally crush in their sides as easily as a segar-box, assisted by *shot-proof gunboats*, also equipped with the heaviest ordnance.

Military science should seek rather to counteract than to imitate, and most thoroughly has it been done in this case. This is no speculation; the 15-inch gun has been made and used successfully, and it is asserted by no less an authority than Major Barnard himself, "that a gun of even twenty inches calibre can probably be made, and not only *made* but used. Will they prove such formidable antagonists to our wooden ships of greater speed and heavier battery? We may successfully counteract their comparative impregnability with *speed* and a judicious arrangement of battery. Speed is a point which now nearly all naval officers acknowledge to be of paramount importance, a surrender of which cannot under any circumstances be permitted. Steam no longer plays a second part; this condition is reversed, and sails are now considered to be auxiliary.

In all vessels now being built for the navy, speed under steam is a *sine qua non;* the hallucination of *auxiliary steam power* has been exploded, and already steps have been taken to greatly increase the speed of our large screw frigates. The arguments which the writer in the *Cornhill Magazine* for Feb., 1861, uses to prove the great advantages of the *Warrior* over the *Gloire* would apply, according to his reasoning, almost as forcibly to a *swift* well armed screw frigate as they do to the *Warrior* herself. It is not possible, other things being equal, for an iron-clad shot-proof frigate, loaded as she is with both armor and battery, to be equal in speed to a wooden frigate burthened only with her battery, and even a heavier one.

It is worse than useless for us to waste millions of dollars on *Gloires* and *Warriors*. We perceive and understand fully the functions which shot-proof iron-clad vessels are destined to perform, namely, as *auxiliaries* to our navy and fortifications, in the defence of our harbors, bays, coasts, and adjacent waters, from any attack which may be made by any fleet, no matter how large. The more we examine the question the more we are convinced that the whole matter of iron-clad vessels, in both France and England, has been a game of "brag;" they have built vessels useful only to intimidate each other, formidable to no one else; indeed, it would not be a great exaggeration to say that they

* For a description of this gun, see "Notes on Sea Coast Defence," by Major Barnard, U. S. A.

were built more with a view to their own safety than to be terrible to their enemies.

The excitement created in England by the appearance of this solitary vessel, and the announcement that some more were to be built, is hardly to be credited. Think of the millions that are now being spent there upon both forts and iron-cased steamers; they are not willing to substitute entirely a perishable for an imperishable defence, and if the skill and judgment of the U. S. Engineers and the system of sea coast defence inaugurated nearly forty years since needs an endorsement, it has it here.

This paper could not be regarded as complete if it omitted to mention that notable structure, the Stevens Battery, which has become almost a household word. Probably no enterprise in which the government has ever been interested has attracted so much attention and caused so much speculation; this no doubt has been occasioned principally by the impenetrable mystery which has surrounded it, and the strict secresy with which those parts already constructed have been built; even the government itself had no thorough knowledge of what was going on.

Now that the veil has been lifted by the Board of Commissioners appointed by the Secretary of the Navy to examine and report upon it, curiosity is at least satisfied. This Board was composed of Commodores Stringham and Inman, Captain Dornin, and Chief Engineer Stimers, U. S. N.,and Professor Henry, of the Smithsonian Institute. This latter gentleman made a minority report.

However much credit is due to Mr. Stevens for priority in suggesting the feasibility of constructing shot-proof vessels, by coating them with iron, the present structure and the various plans proposed for its completion have been the work of the last few years.

The Battery, as far as completed, consists of a long, slender, iron vessel, without decks, the entire central portion filled with engines and boilers. The vessel is provided with two independent screws, which by revolving them in opposite directions, will cause the ship to turn around in nearly her own length.

It was the intention of her projector, by supplying her with immense power and by giving her the sharpest ends ever constructed, to produce a speed unrivalled in the history of navigation.

As is already well known, the Board reported against the completion of the vessel upon the plans proposed. This report is exceedingly thorough and is very much in detail; at the same time it must be said that it is quite impartial and just. The description of the vessel and the plans proposed to complete her, which occupy the first part of the report, were warmly commended by the parties themselves, on account of its perfect accuracy. So the correctness of the criticisms which form the latter part of it, and the conclusion which condemns the completion upon the plans proposed, may be judged accordingly. These plans must have been of very recent origin, as they differ materially from those advanced by her projector, R. L. Stevens, Esq., deceased.

It was the intention of her projector to have vertical sides above water, pierced with gun ports; the inclined armor and the plan of having the guns exposed *en barbette* on top of the vessel appears to be of very recent date.

The principal points upon which the Board condemned it, form radical parts of the entire plan, and which cannot be obviated without entirely reconstructing those parts already completed, (which are in fact nothing more than the hull of an unusually sharp iron steamer, with the steam machinery,) are, first, Great deficiency in strength, both as regards sea-going qualities and the ability to support the armor proposed. Second, The plan of mounting the guns *en barbette*, with nothing whatever to screen them from the view of the enemy, and depending upon their immense size to protect them from destruction when struck by shot. Experiments tried at Woolwich, England, in 1857, prove that masses of cast iron nearly as large as the 15-inch gun were entirely destroyed by shot from the 68-pounder gun. Third, That the vessel would not be in all parts and at all times shot-proof.

These objections involve many important minor ones, which from the space allotted to this paper cannot be enumerated.

One is, however, that the fact of having the guns exposed entails the necessity, for the protection of the gunners, of having them manipulated, both as regards loading and training, by complicated machinery placed below the deck upon which they are mounted, only one man to each gun to aim and fire it being on deck in time of action.

Whatever may be the theoretical advantage of the plan of partially sinking the vessel to secure the additional protection of the water, in time of action, it is impracticable, for reasons well pointed out by the Board; besides, it would be far better to make the vessel perfectly shot-proof, without depending on such a plan for her protection when in presence of the enemy; indeed, there might be times when the weather would preclude this partially sinking.

Congress have acted very judiciously on the subject of iron-clad vessels, evidently unwilling to vote immense sums of money to be expended on projects of doubtful success. At the special session last summer, however, an act was passed authorizing the Secretary of the Navy to advertise for proposals to construct one or more iron-clad shot-proof vessels—each one proposing to furnish his own plans; it was also provided that these plans should be approved of by three commanding officers of the navy, and a board was appointed for this purpose, consisting of Commodores Smith and Paulding, and Captain Davis. $1,500,000 was appropriated to build such as were approved of. Three were selected, all different from each other.

Among these was one presented by the eminent engineer, Ericsson. In designing this vessel he displayed that thorough knowledge of mechanical philosophy which is the most strongly marked trait of his character, and which has not probably been possessed to so great an extent by any engineer since the days of Watt; this same knowledge he so successfully brought to bear upon the introduction of the screw propeller, constructing one long before the tedious experiments

upon this subject tried by England and France had been performed, and which only proved that the principles adopted by him were correct.

Every American will remember with pride the old frigate *Princeton*, the first screw steamship of war with her machinery placed entirely below the water-line, out of the reach of shot; the first which burned anthracite coal, avoiding that dense smoke which even now reveals plainly for miles the position of all foreign war steamers; the first provided with a telescopic funnel, which could be lowered out of the way of the sails; the first that used blowers, thus making the supply of steam perfectly independent of the smoke pipe; in fact, the first really successful application of the screw to vessels of war. She was provided with *direct-acting engines*, which worked beautifully for years. Ericsson at an early day saw their advantages, and was the first who coupled the screw directly to the engines. This vessel, as almost every one knows, was designed by Ericsson over twenty years ago.

So when the problem of shot-proof vessels arose, he perceived at once the duties required of such a vessel, and, instead of proceeding as his predecessors have done, in loading down vessels of the *ordinary form* with the immense weight of shot-proof armor required to entirely cover them, he adopted at once the shape which gives the greatest possible buoyancy with the smallest area of target. A broad, flat-bottomed vessel, with perpendicular sides and regular pointed ends, requires but little depth to displace a sufficient quantity of water to buoy itself up, loaded with shot-proof armor on its sides, and a bomb-proof deck, upon which is placed a shot-proof revolving turret, armed with two of the heaviest guns.

This is what is termed the upper vessel; its length is 172 feet, breadth 41 feet, and depth 5 feet. The sides of this vessel are formed first of plate iron ½-inch thick, next to which is fastened solid oak 26 inches thick; this oak then receives the shot-proof armor of rolled iron in five laminæ of 1 inch thick each. The deck, which is bomb-proof, is composed first of white oak beams 10 inches square, and 26 inches apart between the faces, upon which is placed planking 7 inches in thickness, and finally the whole is covered with a layer of rolled iron 1 inch thick.

The bottoms of these beams are on a level with the water, so that the armor above water has a wooden backing of 41 feet. It will be seen that, instead of having the compound curves and great surface of an ordinary modeled vessel to plate, and which in fact are almost utterly impossible to cover properly, every part is straight, or has curves in one direction only, so the heavy armor can be applied with great facility.

To appreciate this great advantage of *simplicity of form*, it is only necessary to see the rapidity with which the heavy plates are fitted and secured.

This upper vessel will be 3 feet 6 inches under water, thus leaving but 1 foot 6 inches above the surface. Now, if this vessel which we have described could be anchored in any desired position, we would

have all that is required. Therefore, to give such a vessel the space required to carry her steam machinery, fuel, stores, and the quarters for the officers and men, it is only necessary to secure beneath it a vessel of ordinary strength.

This is what is termed the lower vessel; it is 124 feet long, 34 feet in breadth at its junction with the upper one, 18 feet at the bottom, and 6 feet 6 inches deep.

In speaking of these as the upper and lower vessels, it must not be supposed that they are built separately; they make together one vessel; it is only as regards the form of the vessel that they can be spoken of as two.

It will also be perceived that the lower vessel is much narrower than the upper one at their junction, and that its sides are very sloping; this is done so that if the enemy's projectile, such as the Whitworth bolt, should possibly pass below the upper shot-proof vessel, the sides of the lower one would be struck at such an acute angle that no damage could occur. The same provision is also made at both the bow and stern.

The upper vessel projects far enough over the bow of the lower one to contain a circular aperture, in which the anchor is hoisted by a capstan in the bow of the lower vessel; at the stern it also projects far enough to thoroughly protect the rudder and screw.

There will be two blowers, drawing their supply of air through bomb-proof gratings in the deck above; one to create a draft for the boilers, and the other to ventilate the ship. The smoke and gases from the boilers pass through bomb-proof gratings in the deck.

The entire vessel is divided near the centre by a strong wrought iron bulkhead, on the after side of which are the steam machinery and coal, and forward the quarters for the officers and men (which are quite comfortable and spacious), and the store rooms, magazines, &c.

The revolving turret is composed of a rolled iron skeleton 1 inch in thickness, to which is riveted and bolted eight laminæ of rolled plates each 1 inch thick. These plates are very accurately fitted up, the seams are vertical, and the joints so arranged as not to come in the same line. The top is made bomb-proof by being covered with a bomb-proof roof placed six inches down in the cylinder.

The diameter of the interior of the turret is 20 feet, and the height from the deck 9 feet. Within this turret are two 11-inch Dahlgren smooth-bore guns, but 15-inch guns could be mounted in it.

Two enormous wrought iron pendulums are so arranged that when the gun recoils they will swing by and effectually close the portholes. The general reader may ask, Why are not there those terrible rifle guns,* about which so much has been said? The reason simply is, that spherical shot are much more efficient at short ranges than rifled ones are at any range, and as this vessel is shot-proof, she will engage the enemy at a distance of from 300 to 400 yards.

* Notwithstanding how much we have heard of Armstrong and other rifled guns, the Dahlgren rifled 150-pounder, of 16,000 pounds weight, from its extreme simplicity and beauty of workmanship, is far ahead of any species of rifled gun ever yet constructed; it is cast without trunnions or cascable, to avoid the strain caused by protuberances in castings, without an angle to mar its beautifully curved outline. To those who have a mechanical eye, and can appreciate simplicity, this gun will be viewed with the greatest admiration.

Her draft of water is ten feet. It is expected that she will have a speed of eight knots. She is not intended as a cruiser, but can proceed safely by sea to any part of our coast during the roughest weather. The bomb-proof gratings for the furnaces and blowers at such times will be protected by suitable pipes, to prevent the water from entering if it should come on the deck.

If desirable in those which may hereafter be built, a greater speed can be attained by simply giving more steam power; but it is thought the speed she will possess is ample for all purposes for which this one is intended.

Her cost complete will be $275,000, or about one-eighth the cost of the *Warrior*. Imagine the *Warrior* surrounded by eight such vessels, perfectly shot-proof, sticking close to her, and their 11-inch wrought iron shot smashing in her sides!

The weight of the vessel complete with stores, ammunition, and coal, will be about 1000 tons, the armor alone of the *Warrior* weighs 1300 tons.

This will in all probability be the first sea-going iron-clad shot-proof vessel ever usd in actual warfare. This is the only plan ever yet promulgated which thoroughly protects every vital part of the vessel itself and every body within it.

It will be seen that thus far we have lost nothing by the delay, which has brought forth a form of vessel complying so perfectly with the necessities which are imposed by the heavy armament necessary in obtaining impregnability. We think we have now the principle required; let us proceed cautiously, and correct in those to be built in future any slight defects which this may exhibit themselves in actual use.

NEW YORK, January 15, 1862.

On the Induration and Preservation of Stone. By Messrs. BARTLETT BROTHERS and Co., Camden Town.

From the London Chemical News, No. 101.

Amongst the many efforts to effect the preservation of stone, we respectfully ask you to chronicle our own in the pages of your journal. It would ill become us to disparage other processes, or attempt to laud our own invention, in your columns. We propose, therefore, to confine ourselves to a full description of the invention, the materials we use to accomplish our end, and the behavior of these materials separately and in combination. Enough has been said in this journal to show, from logical and chemical reasoning, that silica must form a principal feature in all efforts to produce an eligible material for purposes of induration. Silica, then, is the principal material in our process, and that in the form of silicate of potash. Of this material in itself we need say but little; but, lest silicate of soda and potash should here be deemed synonymous, we would anticipate our remarks by saying that in this process they are by no means identical, the silicate of soda producing results both unsatisfactory and valueless.

The second material is the aluminate of potash. Of this, in the form of an aqueous solution, we find it stated by all chemical authorities to the present time, that it precipitates an hydrate of alumina, difficultly soluble in excess of the precipitant; and thus we found it behave after forty-eight hours, precipitating most bulkily in heavy solutions, and as much so in proportion in light specific gravities. We need not say how valueless was such a solution commercially, nor tell the difficulties attending the discovery of a simple remedy, so simple as the determination of the particular specific gravity at which it would not precipitate. The behavior of the aluminate with water is remarkable, seeing that one atom of alumina held in perfect solution by say three atoms of water, should be precipitated by the addition of a fourth, or by the withdrawal of one of the three atoms. Such facts we leave to the investigation of those who may be pleased to pursue them further. Suffice it to say, then, that the aluminate used is prepared from a fused compound of alumina and potash, which product, being highly deliquescent, is easily soluble in water, and so nearly neutral as to contain in its best form of manufacture but two per cent. of free potash.

In the combination of silicate of potash and this aluminate of potash consists the process, the consideration of which affords some most interesting details. When silicate of potash, sp. gr. 1·250, and aluminate of potash, sp. gr. 1·200, are mixed together, an instantaneous decomposition takes place, and the result is a solid mass, consisting of silicate of alumina and some free potash. This hardens with extraordinary rapidity, and is a most beautiful example of the great affinity of silica for alumina. But take a solution of a lighter specific gravity, and we find that decomposition does not instantaneously take place. On the contrary, the liquidity of the two solutions in combination is retained for a time, only, however, proportioned to the quantity of water with which it is diluted. Thus, a specific gravity of 1·150 will last as a solution ten hours, while at 1·200 it solidifies immediately. The cause of this arrest of the decomposition—if, indeed, it is arrested—and the peculiar part the water plays in this interchange of elements, will yield a field of interesting inquiry. With the results, however, we have now more immediately to deal; and

Firstly, the time so necessary for manipulation is given in the use of these materials, which in themselves secure an insoluble product by their mutual decomposition.

Secondly, that the agent and re-agent being mixed in one solution, there can be no fear of the one or the other being in excess or unneutralized, as in the use of acid or second solutions.

Thirdly, the product resulting from this combination of silicate of potash and alumina is insoluble in dilute sulphuric and hydrochloric acids.

And, lastly, if Ansten, Bath, and Caen stone or chalk be pounded, this product will recombine them, thus showing that its chemical affinities are in favor of the material with which it is proposed to impregnate the stone.

Finally, in the works of Füch, and the *brochures* of Kühlmann, the foreshadowing of this process may be seen; and in the Report of the Commission appointed to investigate the causes of the decay of the Houses of Parliament, there are mentioned, though not in conjunction, the very materials proposed to be used by this process. We trust that our researches in this direction may prove so successful as to benefit the public at large, and afford its quota of like satisfaction to ourselves.

The Tunnel through Mount Cenis.

From the London Mechanics' Magazine, September, 1861.

A letter in the *Patrie* describes the progress of this great work. The cutting of the tunnel advances day and night with a regularity which excites the admiration of engineers. At the commencement of this great enterprise only the pickaxe and blasting were employed, but since the machines invented by MM. Grattone and Sommellier were brought into use, the cutting of the rock has been carried on with remarkable celerity. The machines, which are worked by compressed air, are very ingenious; they are each of 250 horse power, and act simultaneously on both sides of the mountain. They set in motion different instruments of great power, which operate in any direction that may be required. The section of the tunnel is about 60 metres, and when the cutting was commenced only 12 men could, from the limited space, be occupied at each end, the work they did being only 40 centimetres (about 16 inches) per day; but the machines employ a force equal to 2500 men, and cut out daily two metres—that is, one at each end. In a few months arrangements will be made for making the men employed relieve each other every eight hours, and an electric light will be established; and then the extraction of rock will be three metres per day. The tunnel will be 12 kilometres (7½ miles) in length. It is 1330 metres above the level of the sea, and 1060 below the summit of Mount Cenis. It will gradually rise ½ per 1000 to the centre, descending from that point towards Piedmont on the other. In the centre of the way a small canal has been formed for carrying off the waters which filter through the rock. Every fortnight an examination is made for the purpose of ascertaining the direction of the tunnel and level of the roadway, instruments of great precision being employed in the operation. Thus far the cutting on both sides of the mountain has been found to coincide exactly. The rock is easily penetrated by the machines. When holes of from 40 to 60 centimetres (16 to 23 inches) have been bored, they are filled with gunpowder; the workmen retire to a distance of about 100 metres, and strong doors in iron are closed to prevent fragments of the rock from flying out. Then the mine is fired, and masses of rock are heard to strike against the doors. Afterwards a current of compressed air is driven into the tunnel to expel the smoke, so as to allow the workmen to enter. The removing of the fragments of rock is effected in the way employed on the cuttings of railways, and the machines are again set in motion.

For the Journal of the Franklin Institute.

Experimental Proofs of the Formulæ for several Cases of the Deflection of Solids. By James B. Francis, Civ. Eng.

Engineers are seldom content, in important cases, to rely upon formulæ founded mainly, or even partially, on theoretical considerations, unless they have been tested either by previous practical use, or by experiments made for the purpose. The rules for computing the strength of materials are particularly important to the profession, and great attention has been given of late to the experimental determination of those required for the ordinary questions that arise in practice. With only a slight departure, however, from the ordinary cases, there is seldom any guide excepting mathematical deduction; this is necessarily founded on certain definite assumptions as to the properties of materials, and it is well understood that these assumptions are not strictly correct, and that, consequently, the deductions have not the character of mathematical truths.

Navier, the celebrated Professor at the Polytechnic School in Paris, is one of the most accurate writers on the theory of the strength of materials. In the first part of his *Résumé des Leçons sur l'Application de la Mécanique*, he gives the formulæ for the usual cases, and also for a variety of other cases, some of them very interesting, and only needing the confirmation of experiment to make them useful to engineers. The writer having had occasion to apply some of these formulæ, tested them experimentally, and believing that the results may serve to give confidence in their application to others as well as himself, he has prepared the following account of them:

Formulæ for the deflection of prismatic beams or shafts of wrought iron, supported at each end.

Let W = weight supported at the middle point between the supports, in pounds.
w' = weight uniformly distributed between supports, in pounds.
l = distance between the supports, in inches.
a = breadth of a rectangular beam, "
b = depth " " "
d = diameter of a cylindrical shaft, "
δ = deflection at the middle point between supports, in inches.
π = ratio between the diameter and circumference of a circle.
E = a constant for the same kind of material.

In the formulæ as given by Navier, E has a value eight times that required in Barlow's formulæ (Barlow on the Strength of Materials, 1837). Barlow's scale is adopted in this paper, and also the corresponding co-efficients.

The following formulæ are well established:—

For rectangular beams, with the weight at the middle point between the supports,

$$\delta = \frac{l^3 W}{32\, a\, b^3\, E}. \quad . \quad . \quad . \quad (1)$$

For rectangular beams, with the weight uniformly distributed,

$$\delta = \frac{5}{8} \times \frac{l^3 W'}{32\, a\, b^3\, E}. \quad . \quad . \quad (2)$$

For cylindrical shafts, with the weight at the middle point between the supports,

$$\delta = \frac{l^3 W}{6\, \pi\, d^4\, E}. \quad . \quad . \quad . \quad (3)$$

For cylindrical shafts, with the weight uniformly distributed,

$$\delta = \frac{5}{8} \times \frac{l^3 W'}{6\, \pi\, d^4\, E}. \quad . \quad . \quad (4)$$

The value of E is to be determined by experiment. I take for the purpose, four experiments on a large scale, given in the Appendix to the report made to the British government by the Commissioners appointed to inquire into the application of iron to railway structures, 1849, pages 39 to 46.

In the following table, the value of E is deduced from each experiment, by means of formula (1).

The distance between the supports was 162 inches.

Number of Bar.	Dimensions of Bar.		Weight applied at the middle, producing a deflection of one inch. Pounds. W.	Value of E.
	Depth in inches. *b.*	Breadth in inches. *a.*		
1	1·515	5·523	497 87	3,444,278
2	1·027	5·510	157·27	3,500,888
3	1·522	5·018	464·41	3,487,562
4	1·026	5·050	145·22	3,537,429
Mean value of E, ...				3,492,539

Adopting this mean value of E, we can deduce from formulæ (3) and (4), the following formulæ for the deflection of cylindrical shafts.

With a weight at the middle point between the supports,

$$\delta = 0{\cdot}000\ 000\ 015\ 190\, \frac{l^3 W}{d^4}, \quad . \quad . \quad (5)$$

and with the weight uniformly distributed,

$$\delta = 0{\cdot}000\ 000\ 009\ 494\, \frac{l^3 W'}{d^4}. \quad . \quad . \quad (6)$$

If the weight uniformly distributed is only the weight of the shaft itself, we may substitute for w' its value in terms of l and d.

The weight of a cubic inch of wrought iron being 0·281 pounds,

$$w' = 0{\cdot}281 \times \tfrac{1}{4}\pi d^2 l;$$

substituting this value in (6), we have

$$\delta = 0{\cdot}000\,000\,002\,095 \frac{l^4}{d^2}. \quad . \quad . \quad . \quad (7)$$

To test formulæ (5) and (7), a shaft was selected from a number just finished at the Lowell Machine Shop, and its deflection from a weight at the middle, and also from its own weight alone, was measured and compared with the deflections computed by the formulæ.

The shaft was 16 feet long, and exactly 2 inches in diameter, turned and polished, and without any appreciable irregularity in the part between the bearings.

A substantial frame was erected, having iron bearings to support the shaft, 179·976 inches apart in the clear. A straight edge of white pine, $14\frac{3}{8} \times 2\frac{1}{8}$ inches, was fastened to the posts carrying the bearings, above the shaft; one side of it being in the same vertical plane as the axis of the shaft.

To ascertain the deflection, measurements were taken from the bottom of the straight edge to the top of the shaft over each bearing, as well as at the middle point between the bearings; no appreciable change took place at the bearings, which indicated that the apparatus was stable.

EXPERIMENT 1.—Deflection from a weight applied at the middle point between the bearings.

Weight, . .	26·08 lbs.
Observed deflection, . . .	0·1500 inches.
Deflection computed by formula (5), .	0·1443 "
Difference, . . .	0·0057 "

EXPERIMENT 2.—Deflection at the middle point between the supports, from the weight of the shaft alone.

This experiment required some precautions and corrections not necessary in the first experiment, where the *increased* deflection due to the weight in the middle was all that was required, while in this, the *total* deflection was required.

The shaft might not have been straight when unstrained. To eliminate any error from this source, the apparent deflection was measured four times, the shaft being turned over a quadrant at each measurement after the first; the mean of the four measurements was taken.

The straight edge was made with great care, and was assumed to be straight when unstrained, but it evidently would deflect a little from its own weight when in position. To ascertain the correction, its weight between its supports was ascertained, and the amount it deflected when a certain weight was applied at its middle point was measured; from these data, its deflection from its own weight alone was found to

be 0·0102 inches; which correction should be added to the observed deflection of the shaft.

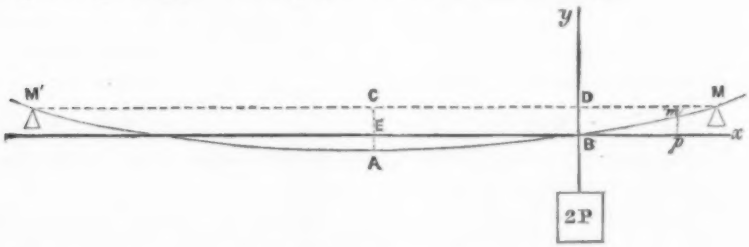
Six inches in length of the shaft, weighing about 5·3 pounds, projected over each bearing; this diminished the deflection at the middle point by an amount equal to that which would be produced by the weight $\frac{5{\cdot}3 \times 3 \times 2}{89{\cdot}988} = 0{\cdot}353$ pounds applied at that point. By formula (5), this deflection would be 0·0020 inch., and this correction must also be added to the observed deflection.

The mean observed deflection, was . .	0·5340	inches.
Correction for deflection of straight edge, .	0·0102	"
" effect of parts of shaft that projected over the bearings, . .	0·0020	"
Corrected observed deflection, . .	0·5462	"
Deflection computed by formula (7), . .	0·5495	"
Difference, . .	0·0033	"

The agreement between the computed and observed results is so near, that they may be considered identical; consequently, formulæ (5) and (7), as well as (1), (3), (4), and (6), from which they have been deduced, may be considered as satisfactorily tested.

Deflection of a rectangular prismatic beam, at the middle point between the bearings, caused by weights applied at one or more points.

Navier gives the following formulæ for the deflection, caused by a single weight, applied at any point between the bearings:



Let a = C M = C M′ = half the distance between the supports.
z = the distance C D.
x = the abscissa B p.
y = the ordinate $m\,p$.
f = B D = the deflection at the point at which the weight is applied.
P = half the weight applied at the point B, in pounds.
b = the width of the beam.
c = the depth " "
E = a constant for the same material, according to Barlow's scale.
$e = \frac{2}{3}\,\mathrm{E}\,b\,c^3$.

The inch being the unit of length.

$$f = \frac{P}{e} \cdot \frac{(a^2 - z^2)^2}{3a} \quad . \quad . \quad (8)$$

Referring to rectangular co-ordinates, the point B being the origin, the equation of the part of the curve B M is

$$y = \frac{P}{e} \cdot \frac{a+z}{a} \left[\tfrac{2}{3}(a-z)zx + \tfrac{1}{2}(a-z)x^2 - \tfrac{1}{6}x^3 \right] \quad . \quad (9)$$

and of the part B M′,

$$y = \frac{P}{e} \cdot \frac{a-z}{a} \left[-\tfrac{2}{3}(a+z)zx + \tfrac{1}{2}(a+z)x^2 - \tfrac{1}{6}x^3 \right] \quad . \quad (10)$$

If the total deflection is small, it is evident that the deflections caused by several weights, applied at different points, may be computed separately, and the sum will be the total deflection.

To test these formulæ, a piece of white pine (*Pinus Strobus*) was selected; it was straight grained, free from all apparent defects, and thoroughly seasoned, having been kyanized seven years previously, and kept under cover during the interval. It was carefully worked to a regular form, and the exact dimensions were—

Distance between bearings	$= 2a =$	120·024	inches.
Width	$= b =$	3·876	"
Depth	$= c =$	3·878	"

A substantial frame was erected, which carried two iron bearings and a straight edge. Plates of iron were placed between the bearings and the beam, to prevent the former from indenting the latter. This, however, did not entirely prevent the pressure from lowering the beam at the ends, and at each observation measures were taken over each bearing, as well as at the middle, and the proper correction made.

To find the value of the constant E for this particular piece of wood, a weight of 100·03 pounds was applied at the middle point. Twenty-four hours after the weight was applied, the deflection produced by it was found to be 0·188 inch.

The value of E can be found from this experiment by formula (1), from which we deduce

$$E = \frac{l^3 W}{32\, a\, b^3\, \delta}.$$

Substituting the data furnished by the experiment, we find

$$E = 127{,}180.$$

Four weights of 50,133 pounds each, were then applied at different points on the beam, viz: one on each side of the middle and 20·004 inches from it, and one on each side of the middle and 40·008 inches from it; the weight of 100·03 pounds remaining at the middle.

When the weight of 100·03 pounds had been on 48 hours, and the other four weights 24 hours, the deflection at the middle point was found to be	. . . .	0·432 inch.
In another 24 hours it had increased to	.	0·443 "
And in 10½ months it had increased to	. .	0·582 "

The following table contains the data and computed results for each weight. The deflection at the middle point, only, having to be computed by formulæ (9) or (10), it can be much simplified, by recollecting that for this point $x = z$.

Number of the weight.	Weight Pounds. 2 P.	Distance of the weight from the middle point between the bearings. Inches. z.	Deflection at the point of application of the weight. f.	Deflection at the middle point, below the axis of x. y.	Whole deflection at the middle point from this weight. Inches.
1	50·133	40·008	0·02908	0·01629	0·04537
2	50·133	20·004	0·07445	0·00582	0·08027
3	100·030	0·	0·18800	0·	0·18800
4	50·133	20·004	0·07445	0·00582	0·08027
5	50·133	40·008	0·02908	0·01629	0·04537
Total computed deflection at middle point, . . .					0·43928

It should be borne in mind that this result depends upon the value of E, which was determined from an experiment in which the weight had been applied 24 hours. As the deflection of wood depends, in some measure, on the length of time the weight has been applied, which is not taken into account in the formulæ, the comparison can be properly made, only, with an experiment in which the weight had been applied about 24 hours also. In the test experiment, when this condition was most nearly complied with, the observed deflection was 0·432 inch, which differs very little from the total computed deflection in the above table.

Formulæ (8), (9), and (10), were also tested by the deflection of a bar of iron, placed in the frame last described.

The bar was purchased as "common English iron," and marked "L. W. refined." Its dimensions were—

Distance between bearings, . .	120·024 inches.
Width, ...	1·238 "
Depth, ...	1·248 "

To find the value of E for this particular bar, a weight of 121·75 pounds was applied at the middle point between the bearings; this caused a deflection of 0·7812 inches, which gives E = 3,499,425.

The weight of 121·75 pounds was then moved to a point 20·004 inches from the middle.

The observed deflection at the middle was then .	0·6664 inch.
The formulæ give . .	0·6655 "
Difference, . .	0·0009 "

The same weight was then moved to a point 40·008 inches from the middle.

The observed deflection at the middle was then .	0·3744 inch.
The formulæ give . .	0·3761 "
Difference, . .	0·0017 "

The weight at the last mentioned point was then increased to 196·87 pounds.

The observed deflection at the middle was then	.	0·6024 inch.
The formulæ give	. .	0·6082 "
Difference,	. .	0·0058 "

These differences are all very small; that in the last trial, which is the greatest, could scarcely be detected with the apparatus used, although the weight was applied at a distance from one of the bearings, equal to only one-sixth of the whole distance between the bearings, and the weight was equal to about one-fifth of the breaking weight, if applied at the middle of the bar.

The measures of the observed deflections in the preceding experiments were made with fine graduated ivory scales; the two final decimals given, result principally from taking means of several measurements.

[Read before the British Association at Manchester.]

Experiments on the Gauging of Water by Triangular Notches. By J. Thomson, A. M., Prof. Civ. Eng., Queen's College, Belfast.

From the Lond. Civ. Eng. and Arch. Journal, December, 1861.

In 1858, I presented to the Association an interim report on the new method which I had proposed for the gauging of flowing water by triangular (or V-shaped) notches, in vertical plates instead of the rectangular notches with level bottom and upright sides in ordinary use.* I there pointed out that the ordinary rectangular notches, although for many purposes suitable and convenient, are but ill-adapted for the measurement of very variable quantities of water, such as commonly occur to the engineer to be gauged in rivers and streams; because if the rectangular notch be made wide enough to allow the water through in flood times, it must be so wide that for long periods, in moderately dry weather, the water flows so shallow over its crest that its indications cannot be relied on. I showed that this objection would be removed by the employment of triangular notches, because in them, when the quantity flowing is small, the flow is confined to a narrow and shallow space, admitting of accurate measurement; and as the quantity flowing increases, the width and depth of the space occupied in the notch increase both in the same ratio, and the space remains of the same form as before, though increased in magnitude. I proposed that in cases in which it might not be convenient to form a deep pool of quiet water at the up-stream side of the weir-board, the bottom of the channel of approach, when the triangular notch is used, may be formed as a level floor, starting exactly from the vertex of the notch, and extending both up-stream and laterally, so far as that the water entering on it at all its margins may be practically considered as still water, of which the height of the surface above the vertex of the notch may be measured in order to determine the quantity flowing.

* See *C. E. & A. Journal*, vol. xxi. p. 369; also, *Journ. Fr. Inst.*, vol. xxxvii. 3d ser. p. 81.

I indicated theoretic considerations which led to the anticipation that in the triangular notch, both with and without the floor, the quantity flowing would be proportional or very nearly so to the $\frac{5}{2}$ power of the height of the still-water surface above the vertex of the notch. As the result of moderately accurate experiments which I had at that time been able to make on the flow in a right-angled notch without floor, I gave the formula $Q = 0{\cdot}317\ H^{\frac{5}{2}}$, where Q is the quantity of water in cubic feet per minute, and H the head of water, as measured vertically, in inches, from the still-water level of the pool down to the vertex of the notch. This formula I submitted at that time temporarily, as being accurate enough for use for many ordinary practical purposes, for the measurement of water by notches similar to the one experimented on, and for quantities limited to nearly the same range as those in the experiments (from about 2 to 10 cubic feet per minute), but as being subject to amendment by future experiments, which might be of greater accuracy, and might extend over a wider range of quantities of water. Having been requested by the general committee of the association to continue my experiments on this subject, with a grant placed at my disposal for the purpose, I have, in the course of last summer and present summer, devoted much time to the carrying out of more extended and more accurate experiments. The results which I have obtained are highly satisfactory. I am confident of their being accurate. I find them to be in close accordance with the law which had been indicated by theoretical considerations; and I am satisfied that the new system of gauging, now by these experiments made completely ready for general application, will prove to be of great practical utility, and will afford for a large class of cases important advantages over the ordinary methods,—for such cases especially as the very varying flows of rivers and streams.

The experiments were made in the open air, in a field adjacent to a corn mill, in Carr's Glen, near Belfast. The water supply was obtained from the course leading to the water-wheel of the mill, and means were arranged to allow of a regulated supply, variable at pleasure, being drawn from that course to flow into a pond, in one side of which the weir-board with the experimental notch was inserted. The inflowing stream was so screened from the part of the pond next the gauge notch as to prevent any sensible agitation being propagated from it to the notch, or to the place where the water level was measured. For measuring the water level a vertical slide wand was used, with the bottom end cut to the form of a hook, the point of which was a small level surface of about $\frac{1}{8}$ inch square. This point of the hook, by being brought up to the surface of the water from below, gave a very accurate means for determining the water level, or its rise or fall, which could be read off by an index-mark near the top of the wand, sliding in contact with the edge of a scale of inches on the fixed framing which carries the wand.

By other experiments a sharp pointed hook, like a fishing-hook, has sometimes, especially of late, been used for the same purpose, and such a hook affords very accurate indications. The result of my experience

however leads me to incline to prefer something larger than the sharp-pointed hook, and capable of producing an effect on the water surface more easily seen than that of a sharp-pointed hook; and on the whole I would recommend a level line, like a knife-edge, which might be from one-eighth to half an inch long, in preference either to a blunt point with level top, or a sharp point. The blunt point which I used was so small, however, as to suit very perfectly. If the point be too large, it holds the water up too much on its top, as the water in the pond descends, and makes too deep a pit in the surface as the water ascends and begins to flow over it. The knife-edge would be free from this kind of action, and would, I conceive, serve every purpose perfectly, except when the water has a velocity of flow past the hook, and in that case, perhaps, the sharp point, like that of a fishing-hook, might be best.

To afford the means for keeping the water surface during an experiment exactly at a constant level, as indicated by the point of the wooden hook, a small outlet waste sluice was fitted in the weir board. The quantity of water admitted to the pond was always adjusted so as to be slightly in excess of that required to maintain the water level in the pond slightly above the height at which the hook was fixed for that experiment. Then a person lying down, so as to get a close view of the contact of the water surface with the point of the hook, worked this little waste or regulating sluice, so as to maintain the water level constantly coincident with the point of the hook.

The water issuing from the experimental notch was caught in a long trough, which conveyed it forward with a slight declivity, so as to be about 7 feet or 8 feet above the ground further down the hill-side, where two large measuring barrels were placed side by side, at about 6 feet distance apart from centre to centre. Across and underneath the end of the long trough just mentioned, a tilting trough 6 feet long was placed, and it was connected at its middle with the end of the long trough by a leather flexible joint, in such a way that it would receive the whole of the water without loss, and convey it at pleasure to either of the barrels, according as it was tilted to one side or the other.

Each barrel had a valve in the bottom, covering an aperture 6 ins. square, and the valve could be opened at pleasure, and was capable of emptying the barrel very speedily. The capacity of the two barrels jointly was about 130 gallons, and their contents up to marks fixed near the top for the purpose of the experiments was accurately ascertained by gaugings repeated several times with two or four-gallon measures with narrow necks.

By tilting the small trough so as to deliver the water alternately into the one barrel and the other, and emptying each barrel by its valve while the other was filling, the process of measuring the flowing water could be accurately carried on for as long time as might be desired. With this apparatus, quantities of water up to about 38 cubic feet per minute could be measured with very satisfactory accuracy.

The experiments of which I have now to report the results were made

on two widths of notches in vertical plane surfaces. The notches were accurately formed in thin sheet iron, and were fixed so as to present next the water in the pond a plane surface, continuous with that of the weir board.

The one notch was right-angled, with its sides sloping at 45° with the horizon, so that its horizontal width was twice its depth. The other notch had its sides each sloping two horizontal to one vertical, so that its horizontal width was four times its depth.

In each case experiments were made both on the simple notch without a floor, and on the same notch with a level floor starting from its vertex, and extending for a considerable distance both up-stream and laterally. The floor extended about 2 feet on each side of the centre of the notch, and about 2½ feet in the direction up-stream, and this size was sufficient to allow the water to enter on it with only a very slow motion, so slow as to be quite unimportant. The height of the water surface above the vertex of the notch was measured by the sliding hook at a place outside the floor, where the water of the pond was deep and still.

H.	Q.	C.
7	39·69	·3061
6	26·87	·3048
5	17·07	·3053
4	9·819	·3068
3	4·780	·3067
2	1·748	·3088

The principal results of the experiments on the flow of the water in the right-angled notch without floor are briefly given in the annexed table, the quantity of water given in column 2 for each height of 2, 3, 4, 5, 6, and 7 inches, being the average obtained from numerous experiments comprised in two series, one made in 1860, and the other made in 1861, as a check on the former set, and with a view to the attainment of greater certainty on one or two points of slight doubt. The second set was quite independent of the first, the various instruments and gaugings being made entirely anew. The two sets agreed very closely, and I present an average of the two sets in the table as being probably a little more nearly true than either of them separately. The third column contains the values of the co-efficient C, calculated for the formula $Q = C\,H^{\frac{5}{2}}$, from the several heights and corresponding quantities of water given in the first and second columns; H being the height, as measured vertically in inches from the vertex of the notch up to the still-water surface of the pond; and Q being the corresponding quantity of water in cubic feet per minute, as ascertained by the experiments. It will be observed from this table that, while the quantity of water varies so greatly as from 1¾ cubic feet per minute to 39, the co-efficient C remains almost absolutely constant, and thus the theoretic anticipation that the quantity should be proportional, or very nearly so, to the $\frac{5}{2}$ power of the depth, is fully confirmed by experiment. The mean of these six values of C is ·3064; but being inclined to give rather more weight in the determination of the co-efficient as to its amount, to some of the experiments made this year than to those of

last year, I adopt ·305 as the co-efficient, so that the formula for the right-angled notch without floor will be $Q = \cdot 305\ H^{\frac{5}{2}}$. My experiments on the right-angled notch with the level floor fitted as already described, comprised the flow of water for depths of 2, 3, 4, 5, and 6 ins. They indicate no variation in the valuation of C for different depths of water, but what may be attributed to the slight error of observation. The mean value which they show for C is ·308, and as this differs so little from that in the formula for the same notch without the floor, and as the difference is within the limits of the errors of observation, I would say that the experiments prove that, with the right-angled notch, the introduction of the floor produces scarcely any increase or diminution on the quantity flowing for any given depth, but do not show what the amount of any such small increase or diminution may be, and I would give the formula $Q = \cdot 305\ H^{\frac{5}{2}}$ as sufficiently accurate for use in both cases. The experiments in both cases were made with care, and are, without doubt, of very satisfactory accuracy; but those for the notch without the floor are, I consider, slightly the more accurate of the two sets.

The experiments with the notch with edges sloping two horizontal to one vertical, showed an altered feature in the flow of the issuing vein as compared with the flow of the vein issuing from the right-angled notch. The edges of the vein, on issuing from the notch with slopes 2 to 1, had a great tendency to cling to the outside of the iron notch and weir board, while the portions of the vein issuing at the deeper parts of the notch would shoot out and fall clear of the weir board. Thus, the vein of water assumed the appearance of a transparent bell, like as of glass, or rather of the half of a bell closed on one side by the weir board, and inclosing air. Some of this air was usually carried away in bubbles by the stream at bottom, and the remainder continued shut up by the bell of water, and existing under slightly less than atmospheric pressure.

The diminution of pressure of the inclosed air was manifested by the sides of the bell being drawn in towards one another, and sometimes even drawn together, so as to collapse with one another at their edges which clung to the outside of the weir board.

On the full atmospheric pressure being admitted, by the insertion of a knife into the bell of falling water, the collapsed sides would immediately spring out again. The vein of water did not always form itself into the bell, and when the bell was formed the tendency to the withdrawal of air in bubbles was not constant, but was subject to various casual influences. Now it evidently could not be supposed that the formation of the bell, and the diminution of the pressure of the confined air, could occur as described, without producing some irregular influence on the quantity flowing through the notch for any particular depth of flow, and this circumstance must detract more or less from the value of the wider notches as means for gauging water in comparison with the right-angled notch with angles at 45° with the horizon. I therefore made numerous experiments to determine what might be the amount of the ordinary, or of the greatest, effect due to the dimi-

nution of pressure of the air within the bell. I usually failed to meet with any perceptible alteration in the quantity flowing due to this cause; but sometimes the quantity seemed to be increased by some fraction, such as 1, or perhaps 2 per cent. On the whole, then, I do not think that this circumstance need prevent the use, for many practical purposes, of notches of any desired width for a given depth.

My experiments give as the formula for the notch, with slopes of 2 horizontal to 1 vertical, and without the floor—

$$Q = 0{\cdot}636\ H^{\frac{5}{2}},$$

and for the same notch, with the horizontal floor at the level of its vertex—

$$Q = 0{\cdot}628\ H^{\frac{5}{2}}.$$

In all the experiments from which these formulæ are derived, the bell of falling water was kept open by the insertion of a knife or strip of iron, so as to admit the atmospheric pressure to the interior. The quantity flowing at various depths was not far from being proportional to the $\frac{5}{2}$ power of the depth, but it appeared that the co-efficient in the formula increased slightly for very small depths, such as one or two inches. For instance, in the notch with slopes 2 to 1 without the floor, the co-efficient for the depth of 2 inches came out experimentally 0·649, instead of 0·636, which appeared to be very correctly its amount for 4 inches depth. It is possible that the deviation from proportionality to the $\frac{5}{2}$ power of the depth, which in this notch has appeared to be greater than in the right-angled notch, may be partly due to small errors in the experiments on this notch, and partly to the clinging of the falling vein of water to the outside of the notch, which would evidently produce a much greater proportionate effect on the very small flows than on great flows. The special purpose for which the wide notches have been proposed is to serve for the measurement of wide rivers or streams, in cases in which it would be inconvenient or impracticable to dam them up deep enough to effect their flow through a right-angled notch. In such cases I would now further propose that, instead of a single wide notch, two, three, or more right-angled notches might be formed side by side in the same weir board, with their vertices at the same level. In cases in which this method may be selected, the persons using it, or making comparisons of gaugings obtained by it, will have the satisfaction of being concerned with only a single standard form of gauge notch throughout the investigation in which they may be engaged.

By comparison of the formulæ given above for the flows through the two notches experimented on, of which one is twice as wide for a given depth as the other, it will be seen that in the formula for the wider notch the co-efficient ·636 is rather more than double the co-efficient ·305 in the other. This indicates that as the width of a notch considered as variable increases from that of a right-angled notch upwards, the quantity of water flowing increases somewhat more rapidly than the width of a notch for a given depth. Now, it is to be observed that the contraction of the stream issuing from an orifice open above

in a vertical plate is of two distinct kinds at different parts round the surface of the vein. One of these kinds is the contraction at the places where the water shoots off from the edges of the plate. The curved surface of the fluid leaving the plate is necessarily tangential with the surface of the plate along which the water has been flowing, as an infinite force would be required to divert any moving particle suddenly out of its previous course.* The other kind of contraction in orifices open above consists in the sinking of the upper surface, which begins gradually within the pond or reservoir, and continues after the water has passed the orifice. These two contractions come into play in very different degrees, according as the notch (whether triangular, rectangular, or with curved edges) is made deep and narrow, or wide and shallow. From considerations of the kind here briefly touched upon, I would not be disposed to expect theoretically that the co-efficient C for the formula for V-shaped notches should be at all truly proportional to the horizontal width of the orifice for a given depth; and the experimental results last referred to are in accordance with this supposition. I would, however, think that from the experimental determination now arrived at, of the co-efficient for a notch so wide as four times its depth, we might very safely, or without danger of falling into an important error, pass on to notches wider in any degree, by simply increasing the co-efficient in the same ratio as the width of the notch for a given depth is increased.

* This condition appears not to have been generally noticed by experimenters and writers on hydrodynamics. Even MM. Poncelet and Lesbros, in their delineations of the forms of veins of water issuing from orifices in these plates, after elaborate measurements of those forms, represent the surface of the fluid as making a sharp angle with the plate in leaving its edge.

MECHANICS, PHYSICS, AND CHEMISTRY.

Extracts from a Paper on the most advantageous form of Magnets. By Dr. Lamont.*

From the Lond. Edin. and Dub. Phil. Mag., November, 1861.

From the determinations it results—

1. That *narrower* magnets are more advantageous than *broader*.
2. That *thinner* magnets are more advantageous than *thicker*.
3. That consequently the most advantageous form is that in which breadth and thickness disappear, and the magnet is transformed into a mathematical line, *i. e.* into a so-called *linear magnet*.

The most advantageous form of a magnet, so far as the proportion of the magnetism to the weight is considered, is therefore an *imaginary* one; practically, however, there are two forms which appear advantageous, namely, the *flat, contracting to a point from the middle*, and the *flat prismatic:* and indeed in the former form the proportion of the magnetism to the weight is more advantageous by one-eighth part than in the latter; so that it must always hold as a rule that the thickness and breadth must be as far diminished as the other necessary conditions permit.

We should still have to investigate in what proportion in the above-

* Translated from Poggendorff's *Annalen*, vol. cxiii. pp. 239–249. Communicated by the Astronomer Royal.

mentioned forms the magnetism stands to the moment of inertia; but I consider it superfluous to annex here the tabular exhibitions relative to this, since without such it is easy to see that the form which we have pronounced as disadvantageous in reference to the weight, must also be disadvantageous as regards the moment of inertia. But as respects the flat form contracting to a point from the middle, and the flat prismatic form, which have been noted above as the only appropriate forms, the weights are, with equal length, and equal breadth in the middle, as 1 to 2, and the moments of inertia as 1 to 3·75, so that the form contracting to a point must be recognised as by far the best.

In regard to the investigation, it ought yet to be mentioned that it must prove always too much dependent on circumstantial details, and too little satisfactory, as long as we are not in a position to lay down the laws of the distribution of the magnetism and of the dependence of the magnetic moment upon the dimensions. In this latter point of view the labors hitherto employed have had only very trifling success. From numerous observations which I have made with the prismatic bars, it results that with equal thickness the magnetic moments are in the proportion of the square roots of the thickness; nevertheless, this law only obtains for greater transverse sections, and is perfectly unavailable for smaller dimensions. I have now made substitutions in the formula—

$$\sqrt{\frac{a\,x+b}{x+c}}\,x,$$

where x is the variable dimension, and a, b, c constants; and I find that it very accurately corresponds with observation in small as in great dimensions. Even when laminæ are laid together, this formula represents very well the result, as will be proved by the following table, in which the second series of experiments is calculated by the formula

$$\sqrt{\frac{12{\cdot}80+2{\cdot}46\,n}{n+0{\cdot}218}}\,n.$$

Number of laminæ = n.	Magnetic Moment.		Difference.
	Observed.	Calculated.	
1	3·53	3·54	+ 0·01
2	4·11	4·00	— 0·11
3	4·36	4·34	— 0·02
4	4·65	4·63	— 0·02
5	4·94	4·90	— 0·04
6	5·15	5·16	+ 0·01
7	5·39	5·40	+ 0·01
8	5·61	5 62	+ 0·01
9	5·83	5 84	+ 0·01
10	6·05	6·05	0·00
11	6·27	6·25	— 0·02
12	6·44	6·45	+ 0·01

A practical inference results from the investigation, which I believe deserves to be carefully considered on the part of those who concern themselves with the manufacture of magnetic instruments. A freely movable magnet is to be employed with advantage only so far as the magnetic moment is as large as possible in proportion to the weight. But the more the transverse size is augmented, the greater is the departure from the fulfilment of this condition, and consequently the use of massive magnetic bars must be pronounced inadmissible. There is only one means of obtaining great magnetic strength with trifling weight; namely, by firmly connecting several thin and flat magnets near or upon one another in one system without their touching each other. Many years ago I began in magnetic variation instruments, later also in magnetic theodolites, to unite several magnets; and at present I use universally systems of three laminæ, which are laid upon each other and held separated in the middle by small pieces of brass of about the thickness of three-quarters of a line. Also in ships compasses several needles near each other are at present continually used with the best result. Hollow cylindrical magnets, to which some artists have given a great preference in regard to strength and lightness, remain, as can be proved even from theoretical considerations, very far behind in comparison with a single flat needle; and with this agree also the experiments which I have made.

Upon the Merits of the "Beam" Steam Engine as compared with the "Direct-Action" arrangements, as a Motive Power for Driving Machinery used in various Manufacturing Purposes. By W. B. JOHNSON.

From the Journal of the Society of Arts, No. 463.

The importance of ascertaining, as far as our present progress in mechanical engineering will allow, the best arrangement of stationary engine upon the reciprocating principle, will be apparent to all that have given the subject consideration. But two views are of great weight at the present time: one is the increasing demand that is being made upon motive power for driving machinery made to take the place of manual labor. The unsettled condition and increasing value of labor in this country make it almost imperative that manufactures in every department should be produced with as little dependence as possible upon labor. This is a movement that will eventually call forth a large amount of motive power, and a motive power differing considerably in its arrangement from that now generally adopted. The other view of the subject is of equal importance. If motive power is to be supplied at any thing like a moderate cost, as compared with other classes of machinery, it must assume something of a fixed form, and to such a degree as will induce the maker to apply machinery in its manufacture to a much greater extent than has hitherto been done. This would not only lessen the cost considerably, but at the same time improve the quality of the work. It is now generally admitted that machinery produced by the application of tools is in all respects much

superior to that produced by hand labor. It may safely be asserted that in no class of machinery is less advantage taken of the assistance of tools than in the production of stationary steam engines. Other reasons might be mentioned for giving the subject of this paper careful consideration. The general consent of engineers to the superiority of steam as a motive power over all other agents, and the universal adoption of the reciprocating piston as the best mode of receiving power from the same, are also ample reasons why an attempt should be made to ascertain the best arrangement for applying such motive power to manufacturing purposes.

Locomotive and marine engineers have, within a comparatively few years, made considerable progress in arriving at the most suitable arrangements of the parts composing such engines; but the stationary engine has remained almost in the same condition in which it came out of the hands of its first originators. Locomotive and marine engineers have abandoned the notion that a "beam" is a necessary part of an engine, but that in some mysterious manner an advantage is obtained by conveying the motive power through a beam, appears still to be the opinion of most engineers engaged in the manufacture of stationary engines.

The stationary beam engine, as ordinarily constructed, is one of the most imperfect pieces of mechanism produced in this country; its parts, taken in detail, are frequently specimens of most excellent workmanship, and exhibit considerable skill in the design; but, when considered as a whole, the machine is dislocated, its parts are numerous, far removed from each other, and in many places it depends upon extraneous support for giving it unity and strength. The foundation work and engine-house walls form the greater part of the framework of the engine, and the engine is thereby subjected to casualties which are quite at variance with one's conception of a perfect machine. Its forces are in various directions, the first mover, the piston, moving apparently without reference to its ultimate purpose, the rotation of the crank-shaft; it starts off, at some distance, at right angles with the shaft. As if afraid at once to face its work, it seems to court a circuitous route in preference to a direct one.

The object of this paper is to bring into comparison with the ordinary beam engine the direct-action engine, and to show the superiority of the latter over the former, and also to compare the various arrangements of direct-action engines with each other; and, before proceeding further, it may be proper to state, that the term "direct-action" engine, used in this paper, refers to that particular construction in which the power is conveyed from the piston-rod to the crank by the intervention of a connecting-rod only. The remarks to be made have special reference to condensing engines; preference has been given for some time to direct-action over the beam, for non-condensing engines, the less number of parts in a non-condensing engine making the application of the direct-action principle a simple undertaking.

The principal objections that have been made to the beam engine are:—

1st. The large amount of foundation work required.

2d. The side walls of the engine-house are required to be built of a strength considerably beyond what is required for a direct-action engine.

3d. The height required is in most cases objectionable, interfering with the lights in the rooms next to the engine-house.

4th. The number of parts through which the power is conveyed, and consequent liability to derangement.

5th. The serious results of any breakage, the parts in falling, in almost every instance of break-down, doing considerable if not all the mischief.

6th. The difficulty of observation of and access to the condensing apparatus of the engine.

7th. The entire dependence of the engine upon the foundation and engine-house walls for unity and support, any settlement in the same causing serious difficulty in re-adjusting the parts of the engine affected thereby.

These objections are named to enable a comparison to be made with the direct-action arrangements, and to ascertain how far such objections are removed by this principle of construction. Direct-action engines are of two kinds, vertical and horizontal. In the vertical, the reciprocating movement of the piston is in a vertical line with the crank-shaft, placed either above or below the cylinder. In the horizontal, the movement of the piston is in a horizontal direction; the position of the crank-shaft being constant, does not admit of the distinction just named in the vertical.

The vertical arrangement of direct-action engine requires:—

1st. Considerably less foundation work than the beam engine.

2d. The walls of the engine-house may be built independent of the engine, although in some constructions of this engine the walls are fully as much depended upon as in the beam engine; this is decidedly objectionable.

3d. The height required is equal to that of the beam engine, and it possesses no advantage over the beam engine in this respect, except that the length of the engine-house is less by about one-half.

4th. The number of parts through which the power is conveyed are equal in proportion as 2 is to 5.

5th. The results arising from break-downs are less severe than in the beam engine, although from its construction it is not free from objection on this ground.

6th. The ease of access to the condensing apparatus will greatly depend upon the arrangement adopted in this part of the engine, but the principle admits of a better one than could be applied to the beam engine.

7th. It is independent of the foundation work and engine walls for unity, "except in instances of imperfect construction;" its forces are self-contained, and it does not, therefore, suffer from settlement or changes in the building in which it is placed, to the like extent as the beam engine.

The vertical direct-action engine has the advantage over the beam engine in the 1st, 2d, 4th, and 7th points named, and also a slight advantage in the 3d and 5th points; in reference to the 6th point, "the condensing apparatus," its advantage over the beam engine will entirely depend upon the arrangement adopted for working the air-pump and the relation of its parts.

When the crank-shaft is above the cylinder, these parts may be conveniently arranged so as to be easy of access and observation, and at the same time be within a suitable distance from the cylinder; but when the crank-shaft is below the cylinder, the condenser is far removed from the cylinder, which is an objection to this description of vertical direct-action engine. From this it appears that the best arrangement of vertical direct-action engine is the one having the crank-shaft above the cylinder. A very excellent engine can be made by having the cylinder, condenser, air-pump, and frame-work well secured to one strong foundation plate; such an engine would be compact, yet easy of access to all its parts, and would possess that unity which is absolutely necessary for perfection in every class of machinery. Were it not that the particular position of the crank-shaft is inapplicable in most cases where power is required, this construction of engine would merit the careful consideration of engineers to bring it up to a standard point of perfection.

The horizontal arrangement of direct-action engine, when compared with the beam engines, requires:—

1st. Less foundation work, although this varies according to the different modes of working the air-pump.

2d. The engine is wholly independent of the engine-house walls, consequently they may be reduced to a minimum in strength.

3d. The height required is much less, being from one-third to one-half of that necessary for a beam engine.

4th. The number of parts through which the power is conveyed is reduced in proportion as 2 is to 5.

5th. The results of break-downs are much less destructive, the whole of the working parts being within a limited distance from the floor, and therefore cannot cause any injury in falling.

6th. The condensing apparatus, and all other parts of the engine, are easy of observation and access, except in some arrangements about to be referred to.

7th. It is independent of the foundation work and engine-house walls for unity; its forces are self-contained, and it does not therefore suffer from settlement or changes in the building in which it is placed, to the same extent as the beam engine.

The horizontal direct-action engine has the decided advantage of the beam engine in the 1st, 2d, 3d, 4th, 5th, 6th, and 7th points of comparison, and also has some advantages over the direct-action on the vertical arrangement. For general purposes, the crank-shaft is conveniently situated; the lines of movement and position of the working parts are also conveniently placed for observation and access; these considerations point to this arrangement of engine as the most

suitable for general adoption, and it merits from engineers and those requiring motive power, that consideration and attention necessary to place it in its proper position as the best arrangement of stationary steam engine.

Various modes have been adopted for working the air-pump in horizontal direct action engines—the relative positions of the condensing apparatus is a question of the utmost importance in endeavoring to make this engine efficient in working, compact and united in its parts, and at the same time easy of access for examination. One arrangement for acccomplishing this consists in working the air-pump from the crank-pin, by a supplementary crank and shaft, and in some cases levers actuated by the crank-pin are employed for this purpose; but either of these, or any other mode of working the air-pump from the crank-pin, are objectionable; the parts of the engine are necessarily separated from each other—there is a want of unity and compactness; the strains are in various directions; the foundation work is considerably extended; and the air-pump and condenser are so far below the engine-house floor as to be inconvenient for examination.

Another mode of working the air-pump is by levers attached by links to the piston-rod, cross-bar, or mounting, in some arrangements of which the fulcrum of the levers is fixed above the horizontal centre line of the engine, and in some below. This may in some respects be superior to the mode first named, but still objection can reasonably be made to the number of parts required, and consequent liability to derangement. The strains are in a variety of directions; it is not united and compact; it requires extra foundation, and is frequently difficult of access for examination.

Perhaps the most correct notion of working the air-pump is that of attaching the air-pump rod direct to the piston-rod, without the intervention of levers, links, or any movable joints. One mode of effecting this is by placing the air-pump a slight distance from the end of the cylinder furthest from the crank-shaft, and attaching the air-pump rod to the piston-rod, which works through the back cylinder cover. This arrangement adds considerably to the length of the engine, and to avoid this, the connecting-rod is frequently made much shorter than is desirable for easy working. Another mode of carrying this arrangement out is effected by placing the air-pump near to the end of the cylinder next to the crank, the piston-rod being continued through the air-pump on to the piston-rod mounting; the air-pump is between the piston-rod mounting and the cylinder end. The same objection applies to this mode, in regard to length, as to the former one, and attempts are made to overcome the difficulty in the same objectionable manner, "shortening the connecting-rod," and by cramping up the parts, so as to make them difficult of access. Another and third mode of working the air-pump direct from the piston-rod, consists in placing the air-pump between the piston-rod mounting and crank, the space between the air-pump and cylinder being sufficient to allow for the working of the piston-rod mounting and guide blocks. The extra length of the engine is not so much as in the former arrangements, and what

extra length is required, is added to the length of the connecting-rod.

The three constructions of engines just mentioned have in common considerable advantages over any other of the direct-action arrangements named in this paper. The foundation is a level bed, less in extent, without any breaks or depressions, and can, therefore, be more firmly bound together; the number of working parts is brought down to a minimum, not exceeding in joints and working surfaces beyond what is required for a non-condensing engine; the liability to derangement is consequently reduced in equal proportion. Every part of the engine is within the limits of easy examination, no part being under the engine-house floor, nor so far above it as to require any stage-work, or second height of flooring. The strains are self-contained, and are all in one direction, and admit of a maximum unity and strength to be obtained with a minimum amount of material.

Other advantages peculiar to this arrangement—"working the air-pump direct"—might be mentioned, but sufficient has been said to show that it possesses claims which entitle it to the attention of all interested in the production and use of stationary steam engines.

Engines have been made upon the various plans referred to, and they have shown in their comparative efficient working most clearly the truth of that almost universally admitted opinion in mechanical engineering, "that the success of a machine is in proportion to its simplicity," of course, supposing correct principles to be adopted in the construction. Engines have been made upon the arrangement last mentioned, in which convenience of access is carried to an extent far beyond what would have been considered possible a few years ago; air-pump foot and delivering valves can be taken out and replaced, air-pump bucket packed, and cylinder-piston examined, within one hour, and without the employment of extra labor beyond what is usual for such purposes. Facilities for examination are next in importance to the good working of an engine, and cannot be too carefully provided for; and, in reference to special and economical working, this arrangement compares most favorably with all other constructions of engines hitherto adopted.

Great freedom has been taken with the beam engine in pointing out some of its defects, or which may fairly be considered objections to it, and it will now only be doing justice to subject the direct-action principle to the same ordeal.

To the vertical direct-action arrangement, no objections can be named beyond those already mentioned, but to the horizontal arrangement an objection was raised at its first introduction, and is still maintained by engineers of undoubted celebrity. The horizontal position of the cylinder is objected to on account of the piston in its movement wearing the lower more than the upper side of the cylinder; now, this is a question that can be best decided by a careful reference to the numerous examples of this kind of engine now at work; facts bearing upon this question can be obtained in almost any quantity, and it is desirable the task should be undertaken to ascertain how far

this objection can be sustained. The horizontal principle in all probability will be extensively adopted for engines of a maximum size, and it would be well to ascertain, before proceeding too far in this direction, the true value of this objection. It has been found that, in all instances in which proper care has been taken, this objection is groundless, and cylinders upon the horizontal arrangement are wearing as equally as those placed vertically. It may be proper to remark that in horizontal engines too much care cannot be bestowed in endeavoring to make the piston and mounting and guide-blocks as perfect as possible. The surfaces should be large, to prevent rapid wearing down, and the construction should be such as will admit of the piston-rod mounting being easily adjusted to its correct centre with the cylinder. With such arrangements, and the parts correctly made and put together, the evils implied in the objection just named are found in practice fully provided against.

No reference has been made to the various kinds of valve arrangements applied to the cylinders of engines, whether beam or direct-acting. The direct-action does not in this respect compare unfavorably with the beam engine; the horizontal arrangement, perhaps, has the advantage of any other in admitting valves of any construction to be applied in a simple and an efficient manner.

Reference has not been made to the other detail parts, the object of this paper being principally to deal with the broad question—Beam *versus* Direct-action; and, on this point, the distinctive features in all the arrangements considered, and those by which the type of the engine is chiefly affected, are, the position and mode of working the air-pump, and, therefore, almost exclusive attention has been given to them.

Before concluding, it may be proper to draw attention to the manner in which most horizontal engines have hitherto been made. The ignorance displayed in many designs, and the imperfect character of the material and workmanship employed, have done much to bring the principle into disrepute; engines of bad construction have been put to a duty far above their capabilities. As a matter of course, they have given no satisfaction, but much trouble, and the principle at last bears the whole of the blame, when, in fact, it has nothing whatever to do with it. The horizontal engine is simple, but that is no reason why it should not be good in design, and of proper materials and workmanship; let the horizontal engine have skilful and careful attention in the design, be well executed, and put to its proper amount of duty, and it will not be long before it attains that position as the best of engines to which its beautiful simplicity so justly entitles it.

Unsinkable and Incombustible Ships.

From the Journal of the Society of Arts, No. 465.

The *Briton*, new screw steamer, destined for the Cape mail service, and now lying in the river off Deptford, is the first specimen of a novel system of ship-building, invented by Mr. Charles Lungley, who

claims for his invention—which is patented—two great advantages, viz: safety from destruction by water, and, to a great extent, security against fire. Each deck of the vessel is distinct from the others, having no communication with them, but having its separate hatchway or entrance from the upper deck; the object of this arrangement being, that whatever injury may be incurred by either one or even by two of these decks or stories, the other or others will float. Thus, for instance, should the lower or keel deck be knocked away, the two upper decks will float the ship; or should, either from a collision, the starting of a plate under the water line, or from a shot or a broadside penetrating the sheathing, one of the intermediate decks let in the water, even to the extent of filling the compartment from stem to stern, the buoyant power would still remain, and the vessel would not only float, but be perfectly manageable, the water merely rising up the trunk hatchway of that particular deck to the level of the water line outside, allowing full opportunity for a diver to descend, find out the place and extent of the injury, and repair it if capable of repair, after which the water might be pumped out and the ship freed.

The same subdivision of decks which affords the security against entire submersion, ensures protection against total destruction by fire. In the event of a fire being discovered on either deck, the hatchway of that deck would be fastened down, and the supply of air being thus cut off, the fire would die out of itself; or if the fire had got too much hold upon the ship to allow of this, then the entire deck in which the conflagration was raging might be filled with water without risk of other inconvenience than that of having to pump it out again.

Another advantage of this mode of ship-building is the perfect ventilation it is said to insure to all parts of the vessel. At present the general practice is to have one main hatchway, which communicates from the upper deck to all the several floors on the ship, and which forms the ventilating shaft from each. It is easy to imagine in cases when fever breaks out on board, how much the danger is likely to be increased by such an arrangement, or when large numbers of troops or emigrants are berthed below, how much the risk of disease is increased by such imperfect ventilation. By Mr. Lungley's plan, each deck has its own ventilating shaft or shafts—for there may be one, two, or more—in the hatchways, which are its means of communication from above. These separate shafts likewise afford facilities for loading and unloading, which will be appreciated in merchant ships.

The practice of dividing iron ships into water-tight compartments, with the view of preventing their sinking, has been followed for many years, but the division walls have in all cases been transverse; that is, each deck has been divided by water-tight iron bulkheads into three, four, or more separate rooms or apartments—the impression being that should one or two become by leakage filled with water, there would be buoyancy enough in the others to keep the ship afloat. Experience has unfortunately, however—and the case of the *Connaught* is a prominent instance among many—proved the unsoundness of this theory. The fact is, that when any one of the compartments becomes

filled with water, or ships water in any considerable quantity, the vessel is unduly depressed in that particular part, and no longer sails with an even keel. To remedy this, it would be necessary to let in a corresponding weight of water in the opposite compartments, which, in all probability, even if practicable, would bring the ship down so low in the water that, with anything like a sea on, she would sink, or the wash from side to side would lay her over on her broadside; whereas, if she were left with her keel out of the level, she would, as the water gained upon her, go down head or stern foremost, as the case might be. By making the decks themselves the water-tight divisions, the weight of water in case of leakage is equalized over the whole surface of the ship, and the even keel, which is the main element of safety, is preserved, while all danger is localized, and thus proportionately reduced.

One thing which strikes the attention of the visitor on board the *Briton*, is the perfect isolation of the engine-room. Not only is it protected by the water-tight deck division, but longitudinal bulkheads or iron walls, running fore and aft some feet within the outer shell or sides of the vessel, protect it from the chance of injury from without. Thus a fracture in the outside plates occasioned by collision, stranding, or shot, although it might admit the water into the ship, would not affect the engines or the fires. The importance of this arrangement of longitudinal inside walls for the protection of the machinery, especially in ships of war, where it may be carried throughout the vessel, for adding to the stability of the entire structure, seems very great. The vessel is now complete, ready for sea, and in the meanwhile her builder, Mr. Lungley, invites those who take an interest in such subjects to inspect her, and, to a large extent, the invitation has been accepted and acted upon by merchant ship-owners, and officers connected with the navy and the merchant service.

Piassava Brooms.

From the Lond. Mechanics' Mag., September, 1861.

For some years past, says the *Technologist*, the streets of London, Manchester, Leeds, Birmingham, and other large towns, have been, in some places at least, kept peculiarly neat and clean by brooms and brushes made of a new material. This material is the coarse, chocolate-colored fibre of the piassaba or piassava, a species of palm which grows in Brazil and Venezuela, near the Casiquiari and neighboring tributaries of the Amazon and the Orinoco. Another kind of piassava, which grows also near the same rivers, yields a finer fibre, which is dyed, mixed with bristles, and used in the manufacture of cheap clothes-brushes, and for hose-brushes. This latter variety is exported from Para, but it forms only a small proportion (not more than four or five per cent.) of the piassava used in this country. The variety used for brooms is shipped chiefly from Bahia, where it is now regarded as a staple export, and is regularly quoted in the Bahia prices current.

Piassava fibre has been used from a very early period for the manu-

facture of cordage in the regions bordering upon the Amazon. The Indians collect it in the forests, and large quantities are used in their villages to form cables for their canoes. These cables are easily made, very durable, and admirably adapted for cordage. Before Brazil became an independent empire, the Portuguese had a factory for the manufacture of piassava into cordage for the use of their arsenal at Para, and as a government monopoly. This cordage is very light, floats upon water, and is more durable in the navigation of rivers than ropes of hemp. It is extensively used in the Brazilian navy.

In England, piassava fibre has been used for about twenty-five years past. At first, its value was unknown, and some of the early arrivals were thrown into the Thames. When a Customs duty was imposed upon it, importers would not take it out of bond. The first bundle of it that arrived in Liverpool had been made up in Para as a "fender," to let down over the bulwarks, to prevent injury by collision or grazing against the sides of other vessels, the dock-gates, quays, &c. This bundle was afterwards thrown upon the quay; a working brushmaker picked it up and made a few brushes from it. These were found to answer so well, that a firm afterwards imported a small quantity, and their speculation was so successful that the sugar-vessels loading at Bahia for Liverpool, began to bring small quantities of it regularly as "dunnage." Thus the trade began about seventeen years ago. Small bundles of about ten pounds each were used to pack between the sugar-boxes and by the sides of the vessels. These at first were sold with difficulty at about £5 per ton. The brushmakers finding the article to be very useful and cheap, demanded a larger supply. At first each vessel brought from five to ten tons, and as the price increased and freights became lower, larger quantities were shipped, some vessels bringing as much as 100 tons. One vessel just arrived in London has brought over 200 tons, and many vessels bring from 50 to 100 tons at a time. It is now carried as freight, and not, as formerly, for dunnage.

The coarser piassava fibre is now brought to this country in bundles of ten to fourteen pounds each. In 1856, 270,071 bundles were shipped at Bahia, and in 1858, 278,417 bundles. It sells at £17 to £18 per ton. The quantity of finer fibre brought from Para reaches some years 150 tons. The selling price is at the rate of £37 to £38 per ton.

The nuts of the piassava tree are also imported from Bahia into England under the name of "coquillas" or coquilhos. Being excessively hard, beautifully mottled with dark and light brown, and capable of taking a very high polish, they are extensively used for turnery work, especially for the handles of bell-pulls, the knobs of walking-sticks and umbrellas, egg-cups, humming-tops, small boxes, and similar articles.

Extraordinary Electric Spark.

The Abbé Moigno, the editor of the Parisian journal *Cosmos*, witnessed an experiment in which the discharge of an induction apparatus constructed by M. Ruhmkorff, capable of giving a spark 18 inches long, pierced a mass of glass two inches thick.—*Cosmos.*

For the Journal of the Franklin Institute.

On some Beams of Uniform Strength.

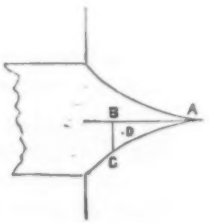
The following problems, although more curious than practical, are interesting illustrations of the *theory of the resistance of beams*. With the exception of the first case, they are new to the writer.

The first case may be found in Robinson's *Mechanical Philosophy*, and "Navier's *Résumé des Leçons*," p. 249, in which the solutions differ from each other, and from the following.

I. General Problem.—*Required the form of a beam of uniform strength; the beam being fixed at one end, and the weight of the beam being the only load.*

1st Case.—Let the breadth be uniform.

Let b = the breadth.
w = the weight of a unit of volume.
y = B C = the variable depth.
x = A B.
D be the centre of gravity.



Then, $\int_0^x y\,dx$ = the area A B C.

$$\frac{\int_0^x x\,y\,dx}{\int_0^x y\,dx} = \text{the abscissa of the centre of gravity D from A.}$$

Now the moment of the load on the section B C is the weight of the beam, A B C, multiplied by the distance of the centre of gravity, D, from the section, which must equal the moment of resistance of the section, which is $\frac{1}{6}\,\mathrm{R}\,b\,y^2$ for rectangular sections.

$$\therefore \quad \left\{ w\,b \int_0^x y\,dx \right\} \left\{ x - \frac{\int_0^x y\,x\,dx}{\int_0^x y\,dx} \right\} = \tfrac{1}{6}\,\mathrm{R}\,b\,y^2. \quad \cdots \quad (1)$$

Expand and differentiate once, and we obtain

$$dx \int_0^x y\,dx = \frac{\mathrm{R}}{6\,w}\,d(y^2).$$

The second differential is

$$\frac{d^2(y^2)}{dx^2} = \frac{6\,w}{\mathrm{R}}\,y. \quad \cdots \quad (2)$$

Let $y^2 = z$. $\therefore\ y = z^{\frac{1}{2}}$. And we have,

$$\frac{d^2 z}{dx^2} = \frac{6\,w}{\mathrm{R}}\,y^{\frac{1}{2}}.$$

Multiply by $2\,dz$, and integrate, and we have,

$$\frac{dz^2}{dx^2} = \frac{8w}{R} z^{\frac{3}{2}} + c\,*. \quad \ldots\ldots\ldots \quad (3)$$

But $\frac{dz}{dx} = 0$ for y or $z = 0$. $\therefore\ c = 0$.

$$\therefore \qquad z^{-\frac{3}{4}}\,dz = \sqrt{\frac{8w}{R}}\,dx,$$

of which the integral is

$$4\,z^{\frac{1}{4}} = 4\,y^{\frac{1}{2}} = \sqrt{\frac{8w}{R}}\,x + c.$$

But $y = 0$ for $x = 0$. $\therefore\ c = 0$.

$$\therefore \qquad y = \frac{w}{2R} x^2, \quad \ldots\ldots\ldots\ldots \quad (4)$$

which is the equation of a parabola, the axis being vertical. It is evident that a similar curve may be formed above, as shown in the figure.

2D CASE.—Let the depth be constant.

Let d = the depth.

u = the variable breadth.

Then we have, for the same reason as before,

$$\left\{ w\,d\int u\,dx \right\} \left\{ x - \frac{\int u\,y\,dx}{\int u\,dx} \right\} = \tfrac{1}{6} R\,u\,d^2. \quad \ldots \quad (5)$$

which, by two differentiations, reduces to

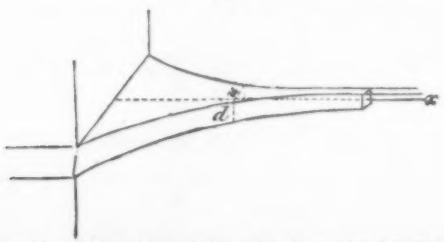
$$\frac{d^2u}{dx^2} = \frac{6w}{R\,d}\,u.$$

The complete integral is

$$x = -\sqrt{\frac{R\,d}{6w}} \log.\left[\sqrt{\frac{R\,d}{6w}\,c + u^2} - u \right] + c',$$

in which c and c' are the constants of integration. We see that the curve is logarithmic. From the nature of the problem, we know that $\frac{du}{dx} = 0$ for $u = 0$. $\therefore\ c = 0$.

$$\therefore \qquad x = -\sqrt{\frac{R\,d}{6w}} \log.\,u + c'.$$



* Can this equation be integrated in finite terms when c is not zero?

If the origin be at the point where $u = 1$, then $x = 0$ for $u = 1$. $\therefore c' = 0$, and the equation becomes

$$x = -\sqrt{\frac{\mathrm{R}\,d}{6\,w}}\log. u.$$

or,

$$u = e^{-\sqrt{\frac{6\,w}{\mathrm{R}\,d}}x},$$

in which $x = \infty$ for $u = 0$; or the beam must be infinitely long before its breadth will vanish.

3D CASE.—Let the sections be circles, or the beam be a conoid of revolution.

We shall obtain

$$\left\{ w \int \pi y^2 dx \right\} \left\{ x - \frac{\int \pi y^2 x\, dx}{\int \pi y^2 dx} \right\} = \tfrac{1}{4}\pi \mathrm{R} y^3.$$

$\frac{1}{4}\pi \mathrm{R} y^3$ is the moment of resistance of a circular section.

By differentiation we obtain,

$$y^2 dx^2 = \frac{\mathrm{R}}{4\,w} d^2(y^3).$$

Let $y^3 = z$, and we readily obtain, by observing that the constants of integration are zero,

$$y = \frac{4\,w}{5\,\mathrm{R}} x^2,$$

which is the equation of a parabola with its axis perpendicular to the axis of the beam.

By comparing it with equation (4), we see that the parameter is $1\frac{3}{5}$ times as great; hence, a beam formed by the revolution of the parabola of the first case about the axis of x, gives a conoid of excessive strength.

4TH CASE.—Let the sections be similar; rectangular, elliptical, or any other form.

This is a more general case than the preceding, but the solution is precisely similar, and we obtain a similar result.

5TH CASE.—Suppose a weight, P, is attached to the free extremity, and the breadth is uniform—the weight of the beam still being considered.

The moment of this weight is

$$\mathrm{P}\,x,$$

which must be added to the first member of equation (1). By differentiating twice, this term disappears, and we finally obtain equation (2), the first integral of which is equation (3), in which C is not zero. As I am unable to integrate this in finite terms, I cannot determine the class of the curve.

6TH CASE.—Let the load be as for the 5th case, but the depth uniform.

The Px must be added to the first member of equation (5), but in the integration, $\frac{du}{dx}$ is not zero, for $u = 0$, but is $\frac{6\,P}{R\,d^2}$, obtained from the equation $P x = \frac{1}{6} R u d^2$. But we may make $x = 0$ for $u = 0$. Hence the curve is

$$x = -\sqrt{\frac{R\,d}{6\,w}} \log. \left[\sqrt{\frac{6\,P}{R\,d^3\,w} + u^2} - u \right] \sqrt{\frac{R\,d^3\,w}{6\,P}}.$$

7TH CASE.—We would proceed in a similar manner if the load were uniformly distributed over its whole length.

8TH CASE.—The problem may be still further complicated by supposing that the beam is uniformly loaded, and has a load at the free extremity.

II. GENERAL PROBLEM.—*Let the beam be fixed at one extremity, and its weight neglected.*

I will consider two cases.

1st. Suppose a weight, P, is applied at the free extremity, and the *moment of inertia* of the sections constant.

We may take any beam whose breadth changes independent of its depth, or otherwise, any beam whose sections are not circles.

Let y = the depth.
u = the breadth.
I = the moment of inertia.
$\frac{1}{2}y$ = the distance of the most remote fibre from the neutral axis.

A a constant depending upon the form of section, and the other constants of the equation.

Then, $R\frac{I}{\frac{1}{2}y}$ is the moment of resistance of the section, equal to

$$A\frac{(u\,y^3)}{y},$$

which equals the moment of applied force, or

$$P x = A\frac{(u\,y^3)}{y};$$

but, $u\,y^3 = C$ = constant;

$$\therefore \qquad P x = \frac{A\,C}{y},$$

which is the equation of a hyperbola referred to its asymptotes, and is the equation of the vertical section of the beam.

From the equation $u y^3 = c$ we obtain,

$$\frac{y^3}{y} = \sqrt[3]{\frac{c^2}{u^2}},$$

which, in the preceding equation, gives

$$p x = a \sqrt[3]{c^2 u},$$

which is the equation of horizontal sections.

2d. We would proceed in the same way if the beam be uniformly loaded, and obtain

$$\tfrac{1}{2} p x^2 = a \frac{(u y^3)}{y} = \frac{a c}{y}. \qquad \text{D. W.}$$

On the Surface-Condensation of Steam. By J. P. Joule, LL.D., F.R.S.

From the Lond. Ed. and Dub. Phil. Mag., November, 1861.

In the author's experiments steam was passed into a tube, to the outside of which a stream of water was applied, by passing it along the concentric space between the steam-tube and a wider tube in which the steam-tube was placed. The steam-tube was connected at its lower end with a receiver to hold the condensed water. A mercury gauge indicated the pressure within the apparatus. The principal object of the author was to ascertain the conductivity of the tube under varied circumstances, by applying the formula suggested by Professor Thomson—

$$c = \frac{w}{a} \log \frac{V}{v},$$

where a is the area of the tube in square feet, w the quantity of water in pounds transmitted per hour, V and v the differences of temperature between the inside of the steam-tube and the refrigerating water at its entrance and at its exit. The following are some of the author's most important conclusions:

1. The pressure in the vacuous space is sensibly the same in all parts.

2. It is a matter of indifference in which direction the refrigerating water flows in reference to the direction of the steam and condensed water.

3. The temperature of the vacuous space is sensibly equal in all its parts.

4. The resistance to conductivity must be attributed almost entirely to the film of water in immediate contact with the inside and outside surfaces of the tube, and is little influenced by the kind of metal of which the tube is composed, or by its thickness up to the limits of that of ordinary tubes.

5. The conductivity increases up to a limit as the rapidity of the stream of water is augmented.

6. By the use of a spiral of wire to give a rotary motion to the

water in the concentric space, the conductivity is increased for the same head of water.

The author, in conclusion, gives an account of experiments with atmospheric air as the refrigerating agent; the conductivity is very small in this case, and will probably prevent air being employed for the condensation of steam except in very peculiar circumstances.

On a newly discovered Action of Light. By M. NIEPCE DE ST. VICTOR.

From the Lond. Edin and Dub. Phil. Mag., November, 1861.

When the freshly broken part of an opaque porcelain plate was exposed to a strong sun for two or three hours, and then placed on chloride of silver paper, after twenty-four hours contact the silver was found to be reduced in the part corresponding to that which had been exposed to light, but there was no reduction in that part which had been preserved from light. Certain fine specimens of porcelain acquire this activity more easily.

A steel plate polished at one part, and roughened at another by the action of aquafortis, and well cleaned by alcohol, was exposed to the sun for two or three hours under the following conditions:—half the polished and unpolished plate under an opaque screen, and the other half under a white glass. The plate was then covered by a paper prepared with albuminized chloride of silver. After twenty-four hours contact, an impression was formed on the unpolished part which had been exposed to the light, but none on the polished part, nor on the unpolished part under the screen. A roughened glass plate carefully cleaned gave similar results.

These experiments show that it is not necessary for the reduction of silver salts that there be a chemical action, as when a metallic salt is insulated with an organic matter. M. Arnaudon has repeated some of these experiments with different gases, and has obtained the same results as with air.

I may here recall a previous observation, that the insulated earth exhibits traces of this action to a depth of a metre, the thickness varying, of course, with the nature of the soil and the degree of insulation. The following experiment supports this view:—In a tin tube lined with pasteboard impregnated with tartaric acid, and insulated so as strongly to reduce silver salts, I placed in the middle of the tube, but not in contact, a small bladder containing a weak solution of starch; after forty-eight hours this starch feebly reduced Barreswil's liquor, while other starch placed in the same conditions, excepting the insulation, produced no effect upon the liquor.

The following experiments were made with a view of trying whether light could magnetize a steel bar, as has frequently been stated. Avoiding all sources of error, a knitting-needle suspended by a hair was entirely unattracted by another needle insulated for a very long time in a beam of light concentrated by a strong lens, whether the light was white or had traversed a violet glass.

I then enclosed a needle in a paper impregnated with nitrate of uranium, or tartaric acid, and insulated; I also suspended a needle horizontally in tubes containing insulated pasteboard; and the results were always negative, as also was the case with experiments made with very feebly magnetized needles in the hope of demagnetizing them.

In conclusion, this persistent *activity* imparted by light to porous bodies cannot be the same as phosphorescence; for, from Becquerel's experiments, it would not continue so long: it is probable that, as Foucault believes, it is a radiation invisible to our eyes, and which does not traverse glass.—*Comptes Rendus*, July 1, 1861.

For the Journal of the Franklin Institute.

Strength of Cast Iron and Timber Pillars: A series of Tables showing the Breaking Weight of Cast Iron, Dantzic Oak, and Red Deal Pillars. By Wm. Bryson, Civ. Eng.

(Continued from page 43.)

Abstract from Mr. Tredgold's table, continued from page 41.

Diameter in inches.	Length or height in Feet.							
	6	8	10	12	14	16	18	20
	cwts.	cwts.	cwts.	cwts.	cwts.	cwts.	cwts.	cwts.
10	2100	2077	2045	2007	1964	1916	1865	1811
11	2550	2520	2490	2450	2410	2358	2305	2248
12	3010	3020	2970	2930	2900	2830	2780	2730

Table showing the calculated weight from Mr. Tredgold's formula, in hundredweights and tons,

$$\frac{9562\,d^4}{4\,d^2 + \cdot 18\,l^2} = \text{W}.$$

Diameter in inches.	Length or height in Feet.							
	6	8	10	12	14	16	18	20
	cwts.	cwts.	cwts.	cwts.	cwts.	cwts.	cwts.	cwts.
10	2100·34	2074·62	2042·45	2004·48	1961·37	1913·89	1862·77	1808·78
11	2548·47	2522·54	2489·98	2451·31	2407 12	2358·08	2304·86	2248·15
12	3039·30	3013·23	2980·35	2941·14	2896·10	2845 83	2790·91	2732 00
	tons.	tons.	tons.	tons.	tons.	tons.	tons.	tons.
10	105·01	103·73	102·12	100·22	98 06	95·69	93·13	90·43
11	127·42	126·12	124·49	122·56	120·35	117·90	115 24	112·40
12	151·96	150 66	149·01	147 05	144·80	142 29	139·54	136·60

Abstract (continued) from Mr. Haswell's table, entitled

"Table showing the Weight or Pressure a Column of Cast Iron will Sustain with Safety."

	Length or height in Feet.							
	6	8	10	12	14	16	18	20
Inch.								
10	245,700	243,009	239,265	234,819	229,788	224,172	218,205	211,887
11	298,350	294,840	291,330	286,650	281,970	275,886	269,685	263,016
12	355,680	353,340	347,490	342,810	339,300	331,110	325,260	319,410

Table showing the calculated weight from Mr. Haswell's formula, in pounds and tons,

$$\frac{10{,}000\,d^4}{4\,d^2 + \cdot 18\,l^2} = \text{W}.$$

Diameter in inches.	Length or height in Feet.							
	6	8	10	12	14	16	18	20
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
10	246,014	243,001	239,234	234,785	229,737	224,175	218,188	211,864
11	298,503	295,467	291,653	287,123	281,948	276,203	269,969	263,327
12	355,995	352,941	349,090	344,497	339,222	333,333	326,901	320,000
	tons.	tons.	tons.	tons.	tons.	tons.	tons.	tons.
10	109·82	108·48	106·80	104·81	102·56	100·07	97·40	94·58
11	133·26	131·90	130·20	128·17	125·86	123·30	120·52	117·55
12	158·92	157·55	155·84	153·79	151·43	148·80	145·93	142·85

Table showing One-Tenth of the Calculated Breaking Weight, in Tons, as deduced from Mr. Hodgkinson's formulæ for Cast Iron Solid Pillars with Flat Ends.

Diameter in inches.	Length or height in Feet.							
	6	8	10	12	14	16	18	20
	tons.	tons.	tons.	tons.	tons.	tons.	tons.	tons.
10	277·38	235·84	200·10	170·38	146·00	126·06	109·71	96·21
11	349·00	301·38	259·20	223·24	193·12	168·05	147·20	129·79
12	428·89	375·37	326·74	284·35	248·15	217·54	191·72	169·92

Table showing One-Fourth of the Calculated Breaking Weight, in Tons, as deduced from Mr. Hodgkinson's formulæ for Cast Iron Solid Pillars with Rounded Ends.

10	563·30	446·54	358·03	291·53	241·16	192·36	157·46	131·63
11	728·20	589·06	479·73	395·29	330·00	275·27	225·32	188·36
12	915·26	753·89	622·91	519·10	437·20	372·27	312·53	261·26

Table showing One-Fourth of the Calculated Breaking Weight, in Tons, as deduced from Mr. Hodgkinson's formulæ for Cast Iron Solid Pillars with Flat Ends.

10	693·45	589·60	500·25	425·95	365·01	315·16	274·29	240·54
11	872·52	753·47	648·01	558·11	482·81	420·14	368·01	324·47
12	1072·23	938·43	816·86	710·87	620·38	543·85	479·31	424·80

Table comparing the Strength of Solid Uniform Cylindrical Pillars of Cast Iron, with Both Ends Rounded and with Both Ends Flat, deduced from the results of Mr. Hodgkinson's experiments on the resistance of solid uniform cylinders of cast iron to a force of compression. **Low Moor Iron, No. 3.**

Length or height of Pillar in inches.	Diameter in inches.	Number of diameters contained in the length or height.	Ends turned so that the force would pass through the axis.		Ends turned flat and parallel to each other.		Ratio of strength.
			Mean break. weight of Pillar in tons.	Mean break. weight per sq inch in tons.	Mean break. weight of Pillar in tons.	Mean break. weight per sq. inch in tons.	
60·5	·50	121·00	·0638	·325			
60·5	·51	118·62			·2174	1·063	
60·5	·77	78·59	·3482	·747	1·0964	2·354	3·14
60·5	·99	61·11	·8791	1·102			
60·5	·997	60·68			2·7848	3·566	
30·25	·50	60·50	·2406	1·225	·7419	3·778	3·08
90·75	1·72	52·76			9·8191	4·225	
90·75	1·76	51·56			10 3477	4·253	
60·5	1·29	46·89	2·5477	1·949	7 1714	5·486	2·81
90·75	2·24	40 51	9·5004	2 410			
60·5	1·535	39·41	4·7544	2·568			
60·5	1·54	39·28	4·9906	2 679			
30·25	·77	39·28	1·2169	2 613	3·9334	8·446	3·23
60·5	1·55	39·03			12·6575	6·708	
30·25	·99	30·55	2·7254	3·540			
30·25	1·01	29·95			9·0669	11·315	
15·125	·76	19·90	4 3508	9·590	8·4834	18·700	1·94
20·1666	1·02	19 77	7·0254	8·706			
20·1666	1·022	19·73			14·6446	17·307	
15·125	·77	19·64	4·5258	9·719	9·9834	21·438	2·20
15·125	·99	15·27	8·8178	11·454			
15·125	1·00	15 12			17·9687	22·878	
10·083	·76	13·26	7·8151	17·229	11·3325	24·983	1·45
10·083	·77	13 09	8·5500	18·363	11·3977	24·479	1·33
7·5625	·77	9 82	10·2446	22·002	13·9263	29·910	1·35
3·7812	·50	7·56	6·7441	34·347	7 7982	39·715	1·15
2·	·52	3 84			10·2084	48 068	
1·	·52	1·92			10·9892	51·715	

Table showing the Strength of Solid Uniform Cylindrical Pillars of Cast Iron with Both Ends Rounded, as deduced from Mr. Hodgkinson's formulæ.

Length or height of Pillar in feet.	Diameter in inches.	Number of diameters contained in the length or height.	Calculated breaking weight in tons from formula, $w = 14{\cdot}9\,\frac{D^{3{\cdot}76}}{L^{1{\cdot}7}}$.	Calculated breaking weight in tons from formulæ, $w = 14{\cdot}9\,\frac{D^{3{\cdot}76}}{L^{1{\cdot}7}}$. $Y = \frac{w\,c}{w + \frac{1}{2}c}$.	Calculated breaking weight per square inch in tons.	Ratio of strength of pillars of same dimensions with *flat* ends.
5	2	30	13·08		4·16	2·56
8	"	48	5 88		1·87	2·56
14	"	84	2·27		0 72	2·56
20	"	120	1·23		0·39	2·57
5	$2\frac{1}{2}$	24	30 23		6·15	2·31
6	"	28·8	22·17		4·51	2·45
5	3	20	60·10		8·50	2·03
6	"	24	44·08		6·23	2·24
7	"	28	33·92		4 79	2·35
8	"	32	27·03		3·82	2·35
14	"	56	10·43		1 47	2·35
20	"	80	5·69		0 80	2·35

Table showing the Strength of Solid Uniform Cylindrical Pillars of Cast Iron with Both Ends Rounded, as deduced from Mr. Hodgkinson's formulæ.

Length or height of Pillar in feet.	Diameter in inches.	Number of diameters contained in the length or height.	Calculated breaking weight in tons from formula, $w = 14{\cdot}9\,\frac{D^{3.76}}{L^{1.7}}$.	Calculated breaking weight in tons from formulæ, $w = 14{\cdot}9\,\frac{D^{3.76}}{L^{1.7}}$, $Y = \frac{w\,c}{w + \frac{3}{4}c}$.	Calculated breaking weight per sq. inch in tons.	Ratio of strength of pillars, same dimensions, with *flat* ends.
5	3½	17·142	107·31		11·15	1·79
6	"	20·571	78·71		8·18	2·01
7	"	24	60·56		6·29	2·18
8	"	27·428	48·26		5·01	2·27
5	4	15		170·80	13·59	1·65
6	"	18	130·03		10·34	1·81
7	"	21	100·05		7·96	1·99
8	"	24	79·73		6·34	2·13
9	"	27	65·26		5·19	2·21
10	"	30	54·56		4·34	2·21
20	"	60	16·79		1·33	2·21
5	4½	13·333		249·99	15·72	1·57
6	"	16		200·51	12·61	1·66
7	"	18·666	155·80		9·79	1·82
8	"	21·333	124·16		7·80	1·97
9	"	24	101·63		6·39	2·09
10	"	26·666	84·96		5·34	2·16
11	"	29·333	72·25		4·54	2·16
5	5	12		348·73	17·76	1·50
6	"	14·4		280·40	14·28	1·60
7	"	16·8	231·54		11·79	1·67
8	"	19·2	184·52		9·39	1·82
9	"	21·6	151·04		7·69	1·95
10	"	24	126·27		6·43	2·05
11	"	26·4	107·38		5·46	2·11
12	"	28·8	92·61		4·71	2·11
20	"	48	38·86		1·97	2·11
5	5½	10·909		468·04	19·70	1·44
6	"	13·090		384·51	16·18	1·53
8	"	17·454	264·05		11·11	1·69
10	"	21·818	180·69		7·60	1·93
12	"	26·181	132·53		5·57	2·07
5	6	10		608·69	21·52	1·39
6	"	12		505·68	17·88	1·47
7	"	14		424·85	15·02	1·54
8	"	16		361·06	12·77	1·60
9	"	18	299·79		10·60	1·70
10	"	20	250·62		8·86	1·81
11	"	22	213·14		7·53	1·91
12	"	24	183·83		6·50	1·99
13	"	26	160·44		5·67	2·03
14	"	28	141·45		5·00	2·03
15	"	30	125·80		4·44	2·03
20	"	40	77·13		2·72	2·03

Table showing the Strength of Solid Uniform Cylindrical Pillars of Cast Iron, with Both Ends Flat, as deduced from Mr. Hodgkinson's formulæ.

Length or height of Pillar in feet.	Diameter in inches.	Number of diameters contained in the length or height.	Calculated breaking weight in tons from formula, $w = 44{\cdot}16 \frac{D^{3.55}}{L^{1.7}}$.	Calculated breaking weight in tons from formulæ, $w = 44{\cdot}16 \frac{D^{3.55}}{L^{1.7}}$ $Y = \frac{w\,c}{w + \frac{3}{4}c}$.	Calculated breaking weight per sq. inch in tons.	Ratio of strength of pillars, same dimensions, *rounded* ends.
5	2	30	33·52		10·66	2·56
8	"	48	15 07		4·79	2·56
14	"	84	5·82		1·85	2·56
20	"	120	3·17		1·00	2 57
5	2½	24		69·99	14·25	2·31
6	"	28·8	54·32		11·06	2 45
5	3	20		122·08	17 27	2 03
6	"	24		98·83	13·98	2·24
7	"	28	79·81		11·29	2·35
8	"	32	63·60		8·99	2·35
14	"	56	24·56		3·47	2 35
20	"	80	13·39		1·89	2·35
5	3½	17·142		192·70	20 03	1·79
6	"	20·571		158·62	16·48	2 01
7	"	24		132·32	13·75	2·18
8	"	27·428	109 95		11·42	2 27
5	4	15		282·98	22·51	1·65
6	"	18		236 53	18·82	1·81
7	"	21		199·68	15 88	1·99
8	"	24		170·35	13·55	2·13
9	"	27	144·58		11·50	2·21
10	"	30	120·87		9 61	2·21
20	"	60	37·20		2·96	2·21
5	4½	13·333		393·64	24 75	1·57
6	"	16		333·64	20·98	1·66
7	"	18·666		284·84	17·91	1·82
8	"	21·333		245 20	15·42	1 97
9	"	24		212·86	13·38	2·09
10	"	26·666	183·62		11·54	2·16
11	"	29·333	156·15		9·82	2·16
5	5	12		525·14	26 74	1·50
6	"	14·4		450·75	22·95	1·60
7	"	16 8		388 84	19·80	1·67
8	"	19·2		337·58	17·19	1·82
9	"	21·6		295·11	15·02	1·95
10	"	24		259·78	13·23	2·05
11	"	26·4	226 98		11·55	2·11
12	"	28·8	195·77		9·97	2·11
20	"	48	82·15		4·18	2·11
5	5½	10·909		677·69	28·52	1·44
6	"	13·090		588·36	24·76	1·53
8	"	17·454		448·45	18·87	1·69
10	"	21·818		349·36	14·70	1·93
12	"	26 181	274·60		11·55	2 07

Table showing the Strength of Solid Uniform Cylindrical Pillars of Cast Iron with Both Ends Flat, as deduced from Mr. Hodgkinson's formulæ.

Length or height of Pillar in feet.	Diameter in inches.	Number of diameters contained in the length or height.	Calculated breaking weight in tons from formula, $W = 44{\cdot}16\frac{D^{3{\cdot}55}}{L^{1{\cdot}7}}$.	Calculated breaking weight in tons from formulæ, $W = 44{\cdot}16\frac{D^{3{\cdot}55}}{L^{1{\cdot}7}}$. $Y = \frac{W c}{W + \frac{2}{3} c}$.	Calculated breaking weight per sq. inch in tons.	Ratio of strength of pillars of same dimensions with *rounded* ends.
5	6	10		851·39	30·11	1·39
6	"	12		746·79	26·41	1·47
7	"	14		656·17	23·91	1·54
8	"	16		578·56	20·46	1·60
9	"	18		512·41	18·12	1·70
10	"	20		456 04	16·12	1·81
11	"	22		407·91	14·42	1·91
12	"	24		366·66	12·94	1·99
13	"	26	326·40		11·54	2·03
14	"	28	287·76		10·17	2 03
15	"	30	255 92		9·05	2·03
20	"	40	156·93		5·55	2·03

Solid Square Pillars of Dantzic Oak, Both Ends being Flat and Firmly Fixed.

Length or height of Pillar in feet.	Side of the square in inches.	Number of diameters contained in the length or height.	Cubical content in feet.	Approximate weight of pillar in lbs.	Calculated breaking weight in tons from formulæ, $W = 10{\cdot}95\frac{D^4}{L^2}$ $Y = \frac{W c}{W + \frac{2}{3} c}$.
5	8	7·5	2·222	104·83	202·19
6	"	9	2·666	125·79	194·94
7	"	10·5	3·110	146·76	187·01
8	"	12	3 555	167·73	178·63
9	"	13·5	3·999	188·69	170·00
10	"	15	4·444	209·66	161·29
11	"	16·5	4 888	230·63	152 64
12	"	18	5·332	251·59	144·18
13	"	19·5	5·777	272·56	135·98
14	"	21	6·221	293·52	128·11
15	"	22 5	6·666	314·49	120·62
16	"	24	7·110	335·46	113·52
17	"	25·5	7·554	356·42	106·83

Solid Square Pillars of Red Deal, Both Ends being Flat and Firmly Fixed.

					$W = 7{\cdot}81\frac{D^4}{L^2}$ $Y = \frac{W c}{W + \frac{2}{3} c}$.
5	8	7·5	2·222	96·76	169·46
6	"	9	2·666	116·12	162·37
7	"	10·5	3·110	135·47	154·71
8	"	12	3 555	154·82	146·73
9	"	13·5	3·999	174·18	138·62
10	"	15	4·444	193·53	130·56
11	"	16·5	4·888	212 88	122·67
12	"	18	5·332	232·24	115·06
13	"	19·5	5·777	251·59	107·79
14	"	21	6·221	270·95	100·90
15	"	22·5	6·666	290·30	94·42
16	"	24	7·110	309·65	88·36
17	"	25 5	7·554	329·01	82·71

(To be Continued.)

On Benson's High Pressure Steam Boiler. By Mr. JOHN JAMES RUSSELL, of Wednesbury.

From Newton's London Journal, September, 1861.

The boiler forming the subject of the present paper, the invention of Mr. Martin Benson, of Cincinnati, U. S., was described at a former meeting of the Institution, in a paper giving the particulars of the application and working of a number of these boilers in America, where they have been in operation from three to four years; about fifty of them being in use for various purposes.

A boiler of this construction having since been erected at the writer's works at Wednesbury, and having now worked satisfactorily for ten months, the further results are given in the present paper. This boiler has been in constant work, driving an engine of 60 indicated horse power; and so thoroughly satisfied was the writer with the results, and the correctness of the principle upon which the boiler is constructed, that he has since erected a second and larger one upon the same plan, but with some improvements in the details, resulting from experience derived from the former boiler. This boiler is now at work on the same premises.

The boiler proper is composed entirely of serpentine tubes, arranged in sections in a vertical plane over the fire. At the front and back of the boilers are doorways for fixing, disconnecting, and taking out the tubes. A circulating pump draws its supply of water from a water and steam receiver, and is worked by a small donkey engine. The lowest tubes of each section of the boiler are connected to the main supply pipe from the circulating pump. The top tubes of each section are joined to the main delivery pipe, and into it the water and steam together are delivered from the tubes, and thence discharged into the upper part of the steam receiver.

The circulating pump is a simple direct-acting pump, with a metallic packed piston, constructed with a single slide valve, instead of suction and delivery valves, so that it is certain and constant in its action; the slide valve is made without any lap or lead, and thus agrees exactly with the motion of the piston. The pump draws its supply of water from the receiver, through the ordinary exhaust port running round the cylinder, and discharges it into the tubes through the main supply pipe. The steam generated in the tubes is driven up with the water through the tubes, and discharged through the delivery pipe into the receiver, where the steam and water are separated; and the water is then again taken by the circulating pump, and returned into the tubes. In starting the boiler, the receiver is supplied with water until its level reaches the fifth or sixth row of tubes from the bottom. As the circulating pump is standing still at first, in consequence of having no steam to work it, the slide valve is allowed to be lifted off its face by the pressure of the water, and lets the water flow past the pump direct through into the tubes. The fire is then lighted, and steam raised from the water in the tubes, which starts the circulating pump to work.

More water is forced through the tubes by the circulating pump than is evaporated in them. The circulating pump of the boiler now used for ten months is double-acting, 6 ins. in diameter, with 9 ins. stroke, and makes 40 revolutions per minute, against a resistance of from 7 to 10 lbs. pressure per square inch; the power required to work it is therefore about ½ horse power, including the friction of the pump. At this speed, it forces through the boiler from 9 to 11 times as much water as is evaporated, which has been found too much to get the greatest efficiency of the boiler; and from 6 to 8 times the quantity evaporated is considered about the proper proportion. In this instance, owing to the construction of the donkey engine, the pump cannot be worked at less than 40 revolutions per minute, at which speed it is fully capable of supplying a 100 horse power boiler at ordinary working pressure, instead of one of only 60 horse power. With high pressure steam, superheated and worked expansively, the pump is large enough for a 150 horse power boiler, in which case ½d per cent., or $\frac{1}{300}$th of the whole power produced is all that is required for working the circulating pump; and with the improved circular bends that have now been adopted for uniting the ends of the tubes in the boiler, there is reason to expect the circulation can be maintained with much less power. No more power is required to work the pump with 80 and 100 lbs. steam than with 20 lbs., since the pressure is the same on both sides of the piston, and the only resistance to be overcome is the friction of the water in the tubes, which of course is increased in proportion to the speed; with the boiler now at work, the resistance on the piston at the proper speed, does not exceed 7 to 10 lbs. per square inch. Originally, the delivery pipe into which the steam and water from the tubes are discharged, was only 5 inches diameter inside, which was found too small; in the present boiler, it has been made 10 ins. diameter. The receiver is supplied with feed water by one of Giffard's injectors, instead of an ordinary feed pump.

It was originally supposed that the mechanical circulation of the water with 9 to 11 times more water forced through the tubes than is evaporated, would be sufficient to prevent deposit, by keeping them washed out clean; and this is the case to a certain extent, as all loose matter is washed by the circulation from the tubes, into the receiver. Some incrustation, however, does take place, but not sufficient to present any practical difficulty, or cause any damage to the tubes. One of the tubes from the first boiler is exhibited as a specimen, showing the amount of deposit that has been formed during the ten months it has been in use. The deposit is greatest in the lower tubes of the boiler, and decreases in the upper rows: practically it is prevented from accumulating so thick as to cause the tubes to be injured by the heat; since it becomes cracked and loosened from the tubes, by their alternate expansion and contraction under the varying temperature of the fire. At times, also, nearly all the water is worked out of the tubes, so as to let them get hot, but not hot enough to cause injury by over-heating; and when the deposit is thus loosened in the tubes, it is washed out into the receiver, by the circulation of the water. The

dirt and scale are cleared out of the receiver by a blow-off cock, which is opened for blowing off two or three times a-day. It takes about a quarter of a minute to free the blow-off cock from the deposit lodged in the receiver, before a full body of water issues from it. Pieces of deposit are blown off which have a circular form, showing that they have been formed in the tubes, and then scaled off and washed into the receiver. The semicircular form of the bends uniting the ends of the tubes, prevents any incrustation lodging in them, by giving an unobstructed passage.

The mode of uniting the tubes together in the former boilers of this construction was with right and left handed screws cut on the ends of the tubes, and screwed into the bends; but this make required an entire section of the boiler to be taken out when a new tube had to be put in; and with large boilers this is too much trouble, owing to weight, difficulty of handling, and impossibility of unscrewing many of the tubes in the bends after they have once been screwed up and put to work. To meet these difficulties, a new form of bend has been made in the present boiler, which admits of any one of the tubes in any part of the boiler being taken out, without removing that section of the boiler, or interfering with any other joints than those of the tube to be removed. Thus, instead of screwing the ends of the tubes, they are made with collars of suitable size welded on, and the ends of the bends are recessed out to receive them: the bends are brought up tight against the collars on the tubes by a centre screw bolt, which passes through a hole in the bend in line with the centres of the two tubes, and is screwed into a cross-bar bearing against the outside face of the collars. The passage through the bend is made on one side of the fixing bolt, to prevent it from obstructing the flow of steam and water. By this plan any of the bends can be taken off through the doorways at the front and back of the boiler, and any tube can be taken out and replaced. The ends of the tubes are passed through end bearing plates, which serve also as shield plates to protect the cast iron bends from the heat of the fire; these plates rest on the walls of the furnace, or are suspended at the top from girders. The joining of the tubes to the main supply and delivery pipes is also effected by collars upon the ends of the tubes fitting into recesses in the main pipes and held up tight by a cross-bar and stud-bolt. By having valves for cutting off the communication between the receiver and tubes, the steam and water can be retained in the receiver during the time of removing a tube; and when distilled water from the surface condenser is used in the boiler, the water can, by this means, be saved if the tube should burst, and be shut off from the boiler while the repairs are in hand.

The special advantage of this boiler is, that steam of high pressure is generated in it with greater safety than steam of low pressure in ordinary boilers. Its construction insures almost perfect safety: for the receiver, the only portion containing any quantity of steam and water capable of causing damage by explosion, is of the strongest form for resisting pressure, of simple construction, and removed from the action of the fire, so that it is entirely free from the injurious

effects of over-heating, and the alterations of expansion and contraction, which are considered to be the cause of so many injuries and explosions of ordinary boilers. The only portion of the boiler exposed to the fire is the tubes, which are of such small capacity that their explosion is incapable of doing any damage, and can only cause the fire to be put out by the water escaping from them. This has been confirmed by the experience with the boiler at the writer's works, where a tube has burst on more than one occasion whilst the boiler and engine were at work; and the effect was so small, that the accident was not immediately perceived, until shown by the loss of steam pressure; the steam and water blowing out upon the fire through the leak in the split tube, and putting it out. The advantages of high pressure steam are now generally recognised; but a much higher pressure than can be obtained in ordinary boilers and superheating of the steam are required to develop these advantages fully, by cutting off the steam earlier with a higher degree of expansion. The economy of expansion is now limited by the weakness of boilers in general use; and a large increase of economy may be obtained if much higher pressures can be safely used.

The leading feature of this boiler is the use of the circulating pump, to maintain a constant and regular circulation of the water through the entire set of tubes forming the heating surface of the boiler. This principle of mechanical circulation is found essential in order to carry out completely the idea of a tubular boiler, in which the heating surface consists entirely of the tubes having the pressure internal, and thereby attaining a maximum of strength and safety with a minimum of material. The rapid generation of steam in the lower portion of such a boiler would so far choke the passage of the tubes as to check the natural circulation of the water, and cause the tubes to be rapidly burnt out. The objection arising at first against the adoption of artificial or forced circulation instead of natural—that it is not self-acting, and may therefore be liable to cause interruption to the working of the boiler—has been satisfactorily proved by the results of the continued working of this boiler to be practically met by the simplicity of construction of the circulating pump previously described. During the ten months that the boiler has been in continual work, this pump has always worked well, and never given any trouble except from causes foreign to its principle of working, such as the water freezing in it, and breaking it. In first raising steam in the boiler, no difficulty is experienced from the circulating pump not being at work, since the tubes do not require circulation of the water until steam is raised, and the pump then starts with a small pressure of steam, so little power being required to work it.

The portability of this boiler is an important practical advantage for several cases of application. The largest piece, the receiver, is only one-tenth the size of an ordinary boiler of the same power, and the tubes can be packed in bundles, giving great advantage for shipping over other boilers, both in the reduction of total weight and in the increased facility for stowage. The economy of space is very great,

and an important advantage in many situations where space is limited and valuable; the space occupied being only one-sixth to one-fourth of that required for ordinary Cornish or cylindrical boilers of the same power.

Owing to the duplication of parts in its construction, the cost of the boiler is but little more than that of ordinary boilers above 25 horse power, including the circulating pump and all the mountings. A small boiler of the kind costs more in proportion than a large one; for in all cases it is best to have an independent circulating pump, and a small pump costs nearly as much as a large one. In this comparison, it is supposed that the steam is worked at the ordinary pressures in both cases, say from 25 to 50 lbs. per square inch; but the suitable working pressure for the new boiler is 100 to 150 lbs. per square inch, with the steam superheated and worked expansively; when thus worked and compared with other boilers in first cost per horse power, the new boiler is much cheaper, and in all cases far cheaper for transporting and setting in masonry. The average thickness of the boiler tubes is not more than $\frac{1}{8}$-inch, and their whole surface is effective heating surface; this results in a great saving of weight compared with ordinary boilers with plates $\frac{3}{8}$ to $\frac{1}{2}$-inch thick. In comparison with marine boilers, the new boiler can be made much cheaper than those on the ordinary mode of construction, while the facility for repair gives a decided advantage.

Though the steam and water from the tubes are discharged together into the receiver, there is a complete separation of them, and there has not been the least trouble from priming. More fully to prove the fact of their separation, cocks have been placed on the upper and lower sides of the delivery pipe leading from the tubes to the receiver: from the upper cock nothing but steam was found to issue, and from the lower nothing but water; and supposing priming to be caused by taking steam from boilers exposed to the direct action of the fire, it is effectually prevented in this boiler for the reason that no fire acts upon the receiver containing the water, from which the steam is taken off, and consequently the water remains in a quiet state. Superheating of the steam is effected by returning the steam from the receiver back to the furnace, and passing it through a sufficient number of superheating tubes, whence it is taken off by a steam pipe to the engine. The superheating tubes are arranged and united together in the same manner as the boiler tubes, and are consequently as simple and convenient to get at for erecting and repairing.

The evaporative duty of the boiler with Staffordshire slack has been $5\frac{1}{2}$ lbs. of water per pound of fuel, without covering the receiver and steam pipes to prevent condensation. Steam has been raised from the time the first shovel of fire was placed in the furnace when cold, without wood or forced draft, to 10 lbs. pressure in twenty-five minutes, when the steam was sufficient to start the circulating pump; in ten minutes more there was 35 lbs. pressure of steam, when the engine was started; and in ten minutes more, being forty-five minutes from the time the first shovel of fire was put in the furnace, all the ma-

chinery driven by the engine was in operation, and there was sufficient steam to produce all the power required. This was with only $\frac{7}{10}$ths of the boiler, or 460 square feet of heating surface, $\frac{3}{10}$ths of the boiler being then not at work. The practice at dinner hours and other times when the engine is stopped, has been to close the damper, open the fire doors, and cover the fire with ashes and slack, and work the circulating pump as slowly as its construction will permit; this entirely prevents generation of steam, and in the meantime saves the tubes from overheating. For starting the engine again, the fire is stirred up, and supplied with coals five or ten minutes before steam is wanted; which is ample time to generate a regular and sufficient quantity of steam to commence working all the machinery driven by an engine of 60 horse power. Steam can be regularly maintained in the boiler that has now been in use for ten months, with a variation of from 10 to 15 lbs. pressure when all the work is on the engine with 40 to 55 lbs. steam in the boiler. The pressure cannot be maintained with quite the same regularity in this boiler as in ordinary boilers, on account of the comparatively small amount of steam room; at the same time it is found that a sufficient quantity of steam is made with regularity enough for all practical purposes.

For the purpose of insuring that the pressure of steam supplied to the engine shall never exceed the intended limit, and of preventing any risk of injury to the engine by over pressure arising from the comparatively small steam room in the boiler, the writer designed a regulating valve, which has been found to fulfil this object with complete success. It consists of a double-beat valve, having a piston below it fixed upon the same spindle, and of the same area as the lower valve, and supported by a spiral spring, which presses the valves open. The steam from the boiler, passing through both the valve seats, is delivered to the engine by a supply pipe; at the same time it acts upon the top of the piston, compressing the spiral spring below to a greater or less extent, according to the pressure of the steam; thus partially closing the valve and wire-drawing the steam whenever its pressure at entrance approaches the intended limit. The spiral spring is adjusted so as to hold the valve full open until this limit of pressure is nearly reached; but whenever that takes place, the partial closing of the vale checks the supply of steam, and prevents the pressure of the steam supplied to the engine from rising above the intended amount. The bottom of the spiral spring is carried by a cylindrical cap, sliding vertically, and supported by the end of a weighted lever, which is adjusted to balance the pressure on the piston at the limit of steam pressure. As soon as the intended pressure is exceeded, this lever is depressed immediately, closing the valve entirely, and shutting off the supply of steam. A safety valve is added on the top of the casing, to make the precaution complete. This regulating valve is in constant work, and maintains the steam supplied to the engine at a uniform pressure. It may also be applied with advantage to low pressure and high pressure engines working in connexion, serving completely to regulate the limit of pressure of the steam supplied to the low pressure engine.

Mr. Russell exhibited specimens of the joints and bends of the boiler tubes, and some of the burst and incrusted tubes that had been taken out of the boiler, as described in the paper.

Mr. J. Fenton observed, that the evaporative duty shown by the boiler was low, amounting to only 5½ lbs. of water per pound of slack.

Mr. Russell said, the boiler was at present very unfavorably circumstanced as to evaporative duty, owing to the steam pipes and receiver not being protected in any way, and much heat from the fire was also lost by passing away into the chimney. The advantage to be obtained by the new boiler in economy of fuel would be fully shown when steam of very high pressure was used, which could be safely done only with a boiler upon that construction.

Mr. G. A. Everitt thought that the consumption of 18 tons of slack per week for an engine of 60 indicated horse power was certainly far from economical; for with Cornish boilers he was burning at his works only 16 tons of slack altogether per week for two engines of 60 nominal horse power, working up to 170 indicated horse power.

Mr. W. Richardson mentioned, that in Green's economizer, which he had used for several years past for heating the feed water by the waste heat passing to the chimney, consisting of a stack of upright pipes placed in the chimney flue, through which the feed water was passed on its way to the boiler, cast iron pipes were first used, but they had tried substituting wrought iron pipes to obtain a thinner metal, that would conduct the heat better; these, however, all became riddled through with small holes in eighteen months, by the destructive action of the condensed water, and had all to be taken out again, and replaced by cast iron pipes. The same result had been experienced at several other places where wrought iron pipes had been tried in the economizer; and he feared therefore the wrought iron tubes in the boiler would be destroyed in the same way by their direct exposure to the fire.

Mr. Russell said there had been such long experience of the use of wrought iron tubes in boilers, that there was no fear for their durability, and they had been found to last for many years working with regular circulation through them. With respect to the degree of superheating obtained, he said that, at 60 or 70 lbs. pressure, the steam was superheated about 220° or 240° by passing through the superheating tubes; and after taking out three sections of the boiler tubes, the steam was superheated more than 500°, having a temperature of more than 900° after passing through the superheating tubes, in consequence of their having in that case a greater extent of surface exposed direct to the fire, while less of the heat was taken up by the boiler tubes.

Mr. C. W. Siemens observed, that the amount of superheating which had been mentioned would go far to explain the low evaporative duty of the boiler; for if the steam were superheated to upwards of 900° by the superheating tubes in their present position close to the chimney, the heat passing away into the chimney must be more than 1000°, which would produce a great loss of fuel. The tubular construction

of boiler, in which the entire heating surface consisted of small tubes, having great strength to resist internal pressure, was, he thought, one that might be advantageously employed, and it had been tried in this country by Dr. Alban many years ago, with steam of 150 to 200 lbs. pressure. In the present boiler, the circulating pump was the novel feature, producing an artificial circulation of the water through the tubes; but he questioned the desirability of introducing such a system, on account of the additional complication involved, and thought the plan might be simplified by some alteration in the arrangement, so as to rely on natural circulation alone.

Mr. Benson said, the special feature of the boiler was the forced circulation of the water, to prevent the tubes ever being short of water; he was satisfied that a boiler of this construction would not last more than five or six months, were it not for the mechanical circulation; for the tubes would soon tear themselves to pieces by unequal expansion and contraction, if exposed to the risk of being alternately full and empty of water, which they would be liable to, if dependent on natural circulation. In the case of water heaters that had been referred to, the tubes were soon eaten through by corrosion, and became forced out of position and twisted round, owing to the small quantity of water passing through them; but no such results had been experienced in the tubes of the boilers, because the quantity of water passed through them by the forced circulation was so much greater than that evaporated. The bottom tubes were made $1\frac{1}{4}$ inches diameter for one-third the height of the boiler, then $1\frac{1}{2}$ inches for the next third, and $1\frac{3}{4}$ inches at the top, which gave an additional security for the bottom tubes being always thoroughly filled with water, while greater freedom of passage was allowed at the top for the mixed water and steam escaping into the receiver.

The chief improvement made since the erection of the first boiler on this construction was, the mode of fixing the tubes in such a manner as to allow of removing and replacing any tube, without taking out an entire section of the boiler: a tube could now be taken out, and a new one put in, in as short a time as 15 to 20 minutes, when the boiler was again ready for work at once.

When the boiler was properly constructed, he had found the evaporative duty was equal to that of any tubular boiler; but in the present instance the boiler was not working under favorable circumstances for economy of fuel. The sections of the boiler were set $1\frac{1}{2}$ inches apart, and much heat escaped between them direct into the chimney. The draft was also deficient, the chimney being only 2 feet diameter, which was too small for the purpose; so that there was not air enough drawn in for thorough combustion of the coal, and smoke generally issued from the chimney for a short time after firing.

A number of air-holes were made in the brick-work on all sides of the furnace, but these were not sufficient to prevent smoke, without a greater force of draft.

Proceedings Mech. Eng. Society.

On Electrical Quantities and Resistance.

From the London Mechanics' Magazine, September, 1861.

A paper, prepared by Mr. Latimer Clark and Sir Charles Bright, "On the principles which should be observed in formation of standards of measurement in electrical quantities and resistance," was read by Mr. Latimer Clark. He said the science of electricity, and the art of telegraphy, have both now arrived at a stage of progress at which it is necessary that universally received standards of electrical quantities and resistances should be adopted, in order that precise language and measurement may take the place of the empirical rules and ideas now generally prevalent. Several standards of resistance have already been proposed, but none have as yet come into universal use, and they have all the disadvantage of being arbitrary in their derivation, or of having no relation to other electrical quantities and measurements. Four electrical standards or units are in reality required; these are mutually dependent on each other, and by their aid every conceivable form of electrical manifestation, whether static or dynamic, and whatever its origin or quantity, can be precisely and definitely stated. They are as follows:—

A. A unit of electrical tension, potential, or electromotive force.
B. A unit of electrical quantity, as applied to static electricity.
C. A unit of electric current, or quantity as applied to dynamic electricity.
D. A unit of electrical resistance.

A.—*The Unit of Electrical Tension, or Electromotive Force.*

It is probable that no more convenient unit of tension could be found than that of a single cell of a Daniell's battery; its electromotive force is but little dependent on temperature, or the strength of solutions, while the continued deposit of fresh and pure copper makes its force remarkably constant. It is moreover a standard which is in constant use, and its energy is so inconsiderable that it would not often require defining fractionally in practice. It is, however, possible to find a more elementary unit. Recent researches have shown, for example, that if a piece of pure zinc be placed in contact with water, or an oxidizing acid, the zinc oxidizes, and in doing so instantly gives off electricity, thereby lowering its own tension, and raising that of the liquid. As soon as the two have acquired a certain definite and constant difference of tension, the oxidation ceases, and the zinc is no longer attacked. If a piece of copper, or silver, or other less oxidizable metal, be placed in mutual contact with the zinc and the liquid, so as to afford a path for the equalization of the tension, the solution goes on constantly, and the continual flow of the electricity from the liquid to the zinc, through the pathway afforded by the copper, forms what is termed a voltaic current. All oxidizable metals have their own specific limit of tension at which they cease to be oxidized, and any of these tensions might be chosen as a unit, but without any practical advantage over that afforded by the Daniell's element. It is scarcely necessary to remark, that the unit of tension is equally applicable to

static electricity, and to the tensions existing at different points in an electric current. The zero of tension is naturally that of the earth at the place and time being, and the degree may be either plus or minus.

B.—*The Unit of Absolute Quantity as applied to Static Electricity.*

There is no natural guide for the formation of this important unit (which is the foundation for the two following), and it is therefore necessary to fix on an arbitrary one. It is well known that the quantity of static electricity—that is, electricity under induction—varies, *cæteris paribus*, directly as the difference of tension between the induced and inducing surfaces. The quantity is also dependent on two other conditions, the difference in the surfaces from each other, and the nature of the interposed dielectric. Let us, for the sake of argument, assume the dielectric to be dry air, the difference of tension to be equal to that of one element of Daniell's battery, the surfaces to be one millimetre, as under, and the area to be one square metre; such a standard would be an arbitrary but not an inconvenient one, and to this unit we could refer all other quantities. In practice this unit would require multiplication by one thousand and by one million. Under this head it is important to observe that any quantity of electricity has a definite existence quite independently of its tension, and when once placed in a body the tension may be raised or lowered or annihilated, or even reversed in its sign from plus to minus, without any change in its quantity; and when the disturbing causes are removed the quantity remains as before.

C.—*The Unit of Electricity in Motion, or Electric Current.*

Having formed a unit of quantity, the definition of this standard becomes simple and obvious; it is formed by a combination of quantity with time. Thus one unit of electricity passing her second naturally forms a unit of current. The practical formation of this standard presents few difficulties. It has been shown by Messrs. Siemens, that when a uniform succession of rapid discharges is sent through a galvanometer, the deflection of the needle is constant and steady. It is easy, therefore, to send a given number of units per second through a galvanometer, and to compare the deflection obtained with that produced by a constant current from a voltaic couple through a given resistance. This method of determining the standard of conductivity has the advantage of being quite independent of resistances. Although it has not yet been put to the test of experiment, there is no reason to doubt that a given quantity of electricity per second will produce an equal deviation of the galvanometer, whether it flow in a continuous stream or in a succession of minute impulses.

D.—*The Unit of Resistance.*

The standard or unit of resistance should necessarily be the same as that of conductivity, or current—that is to say, a wire that will conduct one unit of electricity in one second of time. This would be a very convenient unit for expressing the resistance of the materials used for covering telegraph cables, but would be much too large for defining the resistance of telegraph conductors, and it would require

subdivision by 1000 and 1,000,000, and these resistances would correspond to wires capable of conveying 1000 and 1,000,000 units of current respectively—that is, wires which would, at the usual degree of tension, conduct 1000 and 1,000,000 units of electricity per second. The value of this mutual relationship and dependence will be seen more clearly if we assume a nomenclature for these units, and for this temporary purpose we will derive terms from the names of some of our most eminent philosophers, neglecting for the moment etymological rules. We shall then have the following table:—

A.—*Tension.*

1 Daniell's Element,	= 1 Ohma, or unit of tension.
1000 Ohmas	= 1 Kilohma.
1000 Kilohmas	= 1 Milliohma.

B.—*Quantity.*

1 Ohma, by 1 metre square at 1 Milliometre distance	= 1 Farad, or unit of quantity.
1000 Farads	= 1 Kilofarad.
1000 Kilofarads	= 1 Milliofarad.

C.—*Current.*

1 Farad per second	= 1 Galvat, or unit of current.
1000 Galvats	= 1 Kilogalvat.
1000 Kilogalvats	= 1 Milliogalvat.

D.—*Resistance.*

1 Farad per second,	= 1 Volt, or unit of resistance.
1-1000 Volt	= 1 Kilovolt.
1-1000 Kilovolt,	= 1 Milliovolt.
1-1000 Milliovolt	= 1 Billiovolt.

The ohma, or unit of tension, is practically a very convenient one for all battery purposes: lower tensions, though not often required, may be readily defined fractionally. The kilohma, or the tension of 1000 Daniell's cells, is a convenient one for static electricity and for that of induction coils, as it will pass across a small interval of air. The milliohma is applicable to static electricity of very high tension. The farad, or unit of quantity, is as small a one as is likely to be required in practice. 70 feet of ordinary telegraph wire, with a tension of one cell, would contain about a farad of electricity; 100 farads, if allowed to pass through a very sensitive galvanometer, produce a visible motion of the needle. The kilofarad is a good unit for defining the charge or inductive capacity of submarine cables. The volt, or unit of resistance, is represented by a wire, which would, with a tension of one element, convey a current of one galvat—that is, one farad per second. It would be a useful measure of the resistance of the insulating covering of single miles of cable, although there are some of the most perfect modern cables which offer a still higher resistance. It is, however, altogether too large a unit for the resistance of metallic conductors; it is therefore subdivided into the kilovolt and milliovolt, which last measure is probably small enough to be applicable to the resistances of the conductors of ordinary telegraphic cables. For still smaller resistances it is necessary to have recourse to the billiovolt. The mutual relation and dependence of these units is seen at a glance; thus, at the normal tension, a wire having a resistance of 1 volt, will

conduct 1 farad of electricity per second, or give a current of 1 galvat, and similarly a wire having a resistance of 1-10 kilovolt will give a current of 10 kilogalvats, that is, 10 kilofarads per second; if the tension be doubled or tripled, the quantities will be increased in the same proportion.

The practical introduction of this, or some similar system of notation, would be so great a boon to science and to the art of telegraphy, that it is hoped the British Association will lend its assistance and authority for the settlement of the question, and it is suggested that a committee, composed of members of the Association, should be delegated to examine and report on the whole question at the next annual meeting, with power to confer with English or foreign philosophers, and that funds should be provided for the preparation of standards for public use and reference, a duty in which they would meet with the hearty co-operation and assistance of practical electricians.

Proceedings British Association.

New Marine Glue.

From the Lond. Mechanics' Magazine, September, 1861.

Mr. William John Hay, of Portsmouth Dockyard, has patented his new composition for coating vessels, &c., by permission of the Admiralty, and a company is established for manufacturing it.

The composition is much cheaper than marine glue, and, consequently, cannot fail to be largely adopted by the shipping interest generally. In addition to the purposes to which ordinary marine glue is applicable, the water-proof glue, from its extremely low price, may be used for caulking and paying the seams and decks of all classes of vessels, and will, consequently, become a substitute for the costly marine glue and the inexpensive pitch. Indeed, the purposes for which the glue may be used are almost innumerable; it will be found the cheapest and most durable application for iron, wood, and all other descriptions of roofing and fencing, a good substitute for bottling wax and metallic capsules, and a desirable covering for posts, piles, &c. The glue has been tested by seven years trial, and found to answer the most sanguine expectations. For the information of those who have not proved the superiority of the water-proof glue by actual use, it may be stated that its principal ingredient is Trinidad pitch, or asphalte, which is mixed with vegetable tar and oil naphtha, or a suitable substitute. The best proportions for the ingredients which Mr. Hay has yet discovered are—Trinidad pitch, or asphalte, 60 lbs.; vegetable tar, 15 lbs.; oil naphtha, 2 lbs. Instead of the oil naphtha, 2¼ lbs. of rough creosote, or 4 lbs. of oil of turpentine may be used. In cases where it is required to pack the composition, and send it out for use, and where it may be expected to require remelting and long exposure to heat in the melting pots while being used, he adds an additional ½ lb. of oil naphtha, rough creosote, or oil of turpentine. For paying seams in ships' sides or other upright or nearly upright structures with mops or brushes, a more fluid kind of composition is necessary, which may be obtained by adding to each 20 lbs. of the compo-

sition half a pint of reducing liquid; this liquid is also used to thin down the pitch when long exposure to heat has evaporated a proportion of the vegetable tar and oil. The reducing liquid is composed of vegetable tar 12 lbs., and oil of naphtha (in which ½ oz. india-rubber has been dissolved) 3 lbs. For the oil of naphtha, 3 lbs. rough creosote or 5 lbs. oil of turpentine may be substituted, but the first mixture is preferred. The pitch and tar are heated separately, and well mixed; the oil is then added, and the composition is ready for use.

On Superheating Steam. By L. E. Fletcher, Chief Eng.

From the Lond. Mechanics' Magazine, November, 1861.

At the last ordinary monthly meeting of the executive committee of this association, held on Tuesday, October 29th, 1861, Mr. L. E. Fletcher, chief engineer, presented his monthly report, from which we have been furnished with the following extracts:—

During the past month, 438 engines have been examined, and 595 boilers; 22 of the latter being examined specially, 14 internally, 43 thoroughly, and 516 externally. The following defects have been found:—Fracture, 8 (2 dangerous); corrosion, 36 (7 dangerous); safety-valves out of order, 9; water-gauges ditto, 14; pressure-gauges ditto, 8; blow-off cocks ditto, 54 (1 dangerous); furnaces out of shape, 2; deficiency of water, 2; over pressure, 14—total, 147 (10 dangerous); boilers without glass water-gauges, 13; ditto without pressure-gauges, 10; ditto without blow-off cocks, 59; ditto without feed back press valves, 93. In my last report, I called attention to the application of steam jackets to cylinders, pointing out their importance as an agent "for effecting economy in the use of steam."

I now wish to allude to a kindred and equally important subject—viz: that of *Superheating*, the economy derived from which has now become established by general experience, and in marine engines has, in many cases, effected as high a saving as 30 per cent. I scarcely anticipate such a result as this from its application to Lancashire mill engines; still I am confident that a very considerable saving would be effected, while, at the same time, the vacuum would be improved, the temperature in the hot-wells reduced, and less injection water required, which, to steam users having cooling ponds of limited area, would be most important. These results are mainly due to the prevention of condensation and re-evaporation on the internal surface of the cylinder, as explained in my last report relative to the action of the steam jacket; so that the effect of superheating the steam, or coating the cylinder with a steam jacket, is very similar. The application of the jacket, however, to cylinders, can only be made at the time of construction, except with considerable difficulty, while the principle of superheating can be applied to old engines as an auxiliary without alteration to the existing arrangements.

The subject of superheating has been sadly bugbeared. It has been reported that the use of superheated steam would destroy the surface

of the cylinder, piston, and slides, by preventing lubrication; also, that it would corrode the metal; that it was highly explosive, productive of great pressure, and altogether dangerous and difficult to deal with. Actual experience, however, has proved that these objections are entirely visionary, and I have only within the last few days been assured by the superintending engineer of all the engines and boilers in the large fleet of the Peninsular and Oriental Steam Navigation Company, where superheated steam is now and has, for some time past, been extensively employed, that no difficulty is experienced in its use, and no alteration whatever is required in the old engines, beyond the introduction of a slightly better description of packing for the glands, while not a trace of corrosion has been found. It only now remains, therefore, for the manufacturing engineers of this district to bring out a simple and efficient superheating apparatus, adapted to mill engine boilers, by which they will not only benefit themselves, but at the same time render essential service to the steam users of the district. I am glad to say that one of our members is now laying down a superheating apparatus, and, as soon as I have an opportunity of doing so, I shall be happy to state to the members of the association the results of its actual working as applied to the boilers of an ordinary mill engine, and to assist in the general introduction of this system amongst all our members by affording any other information I am able. I would state, however, in the meantime, that it is found most advantageous to superheat the steam to about 100 degrees above the temperature of plain steam, when no difficulty is found in lubricating; also, that the utmost care must be taken in maintaining the temperature of the steam when once it has been superheated, or the virtue will be lost before it gets to the engine. I found in one case, that although the temperature immediately on leaving the superheater was as high as 600 degrees, yet it had fallen nearly to 300 degrees on its arrival at the engine. I understand that some parties entertain the idea that superheating may be advantageously applied where steam is used for heating purposes. I am convinced, however, that such would not be the case, and that disappointment will inevitably ensue wherever superheating is adopted with this view.—*Assoc. Prev. Stm. Boiler Explosions.*

Water Gauge.

The Committee on Mechanics of the "*Société Industrielle*" of Mulhouse (France), report favorably upon a new form of water gauge submitted to them by MM. Varillat and Langlois. This consists of an iron tube passing horizontally through the front of the boiler to which it is firmly screwed, and terminating externally in an oblong case. Through the interior of this tube passes an iron rod, supported at its inner end on a socket, and at its outer extremity passing through a stuffing-box into the case before spoken of. The inner end of this rod is attached to a hollow float by means of an arm, so that the ris-

ing or falling of the water will cause the rod to rotate on its axis. The outer end also carries an arm, which is connected by means of a slot and pin with an index which moves on an upright guide in the box, and marks the height of the water on a graduated scale.

This apparatus is no improvement so far as we can see upon the old and simple float-indicator invented by Watt, and reproduces the stuffing-box which the gauges of Faber and Grimes were devised to get rid of. As French machinists have borrowed Faber's magnetic gauge (without acknowledgment, of course,) just sufficiently altered in form to render it difficult to recognise at first sight, they had better stick to a good thing, although badly obtained.

Remarks on Radiation and Absorption. By JOHN TYNDALL.

From the Lond. Mechanics' Mag., November, 1861.

To SIR JOHN F. W. HERSCHEL, Bart., &c.

DEAR SIR JOHN:—I am anxious to address this note to you upon a subject which you have in great part made your own, because I fear that neither in my book upon the Alps, nor in my recently published papers, have I made due reference to your estimable researches on Solar Radiation. I have been for some time experimenting on the permeability of our atmosphere to radiant heat, and have arrived at the conclusion that true air, that is to say, the mixture of oxygen and nitrogen which forms the body of our atmosphere, is, as regards the transmission of radiant heat, a practical vacuum. The results from which the opacity of air has been inferred, are all to be ascribed to the extraneous matters diffused in the atmosphere, and mainly to the aqueous vapor. The negative results recently obtained by that eminent experimenter, Professor Magnus, of Berlin, have induced me to re-investigate this point; and the experiments which I have made, not only establish the action of aqueous vapor, but prove this action to be comparatively enormous. Here is a typical case:—On the 10th of this month, I found the absorptive action of the common air of our laboratory to be made up of three components, the first of which, due to the pure air, was represented in magnitude by the number 1; the second, due to the transparent aqueous vapor, was represented by the number 40; while the third, due to the effluvia of the locality and the carbonic acid of the air, was represented by the number 27. The total action of its foreign constituents on the day in question, was certainly sixty-seven times that of the atmosphere itself; while the aqueous vapor alone exerted an action at least forty times that of the air.

I have also to communicate to you some results of lunar radiation which connect themselves with your speculations. On Friday, the 18th of this month, I made a series of observations on the moon, from the roof of the Royal Institution. From six concurrent experiments, I was compelled to infer that my thermo-electric pile lost more heat when presented to the moon than when turned to any other portion

of the heavens of the same altitude. The effect was equivalent to a radiation of *cold* from our satellite. I was quite unprepared for this result, which, however, you will at once perceive may be an immediate consequence of the moon's *heat*. On the evening in question, a faint halo which surrounded the moon, and which was only visible when sought for, showed that a small quantity of precipitated vapor was afloat in the atmosphere. Such precipitated particles, in virtue of their multitudinous reflections, constitute a powerful screen to intercept the terrestrial rays, and any agency that removes them and establishes the optical continuity of the atmosphere, must assist the transmission of terrestrial heat.* I think it may be affirmed that no sensible quantity of the obscure heat of the moon, which, when she is full, probably constitutes a large proportion of the total heat emitted in the direction of the earth, reaches us. This heat is entirely absorbed in our atmosphere; and on the evening in question, it was in part applied to evaporate the precipitated particles, hence to augment the transparency of the air round the moon, and thus to open a door in that direction for the escape of heat from the face of my pile. The instrument, I may remark, was furnished with a conical reflector, the angular area of which was very many times that of the moon itself.

October 21, 1861.

*I was going to add "into space," but the expression might lead to misapprehension. My experiments indicate that the absorption of water is a *molecular* phenomenon. If we suppose the aqueous vapor of the atmosphere to be condensed to a liquid shell enveloping the earth, the experiments of Melloni would lead us to conclude that such a shell would completely intercept the obscure terrestrial rays. And if the vapor be equally energetic, our atmosphere would prevent the *direct* transmission of the obscure heat of the earth into space. On this point, however, I wish to make some further observations.

New Tracing Paper.

It is recommended to moisten a sheet of common paper with benzine by means of a sponge. The paper becomes temporarily transparent, and any lines may be traced through it. In a few hours, the benzine evaporates, and the paper becomes opaque as before.

Cosmos.

On the Surface Condensation of Steam. By J. P. Joule, LL.D., F.R.S.

From the Lond. Mechanics' Magazine, November, 1861.

In the author's experiments, steam was passed into a tube, to the outside of which a stream of water was applied, by passing it along the concentric space between the steam-tube and a wider tube in which the steam-tube was placed. The steam-tube was connected at its lower end with a receiver to hold the condensed water. A mercury gauge indicated the pressure within the apparatus. The principal object of the author was to ascertain the conductivity of the tube under varied circumstances, by applying the formula suggested by Professor Thomson,

$$c = \frac{w}{a} \log \frac{V}{v}$$

where a is the area of the tube in square feet, w the quantity of water in pounds transmitted per hour, v and v the differences of temperature between the inside of the steam-tube, and the refrigerating water at its entrance and at its exit.

The following are some of the author's most important conclusions.

1. The pressure in the vacuous space is sensibly the same in all parts.

2. It is a matter of indifference in which direction the refrigerating water flows in reference to the direction of the steam and condensed water.

3. The temperature of the vacuous space is sensibly equal in all its parts.

4. The resistance to conductivity must be attributed almost entirely to the film of water in immediate contact with the inside and outside surfaces of the tube, and is little influenced by the kind of metal of which the tube is composed, or by its thickness up to the limits of that of ordinary tubes.

5. The conductivity increases up to a limit as the rapidity of the stream of water is augmented.

6. By the use of a spiral of wire to give a rotary motion of the water in the concentric space, the conductivity is increased for the same head of water.

The author, in conclusion, gives an account of experiments with atmospheric air as the refrigerating agent; the conductivity is very small in this case, and will probably prevent air being employed for the condensation of steam, except in very peculiar circumstances.

Proc. Roy. Soc.

FRANKLIN INSTITUTE.

Proceedings of the Stated Monthly Meeting, January 16, 1862.

M. W. Baldwin, Vice President, in the chair.

Isaac B. Garrigues, Recording Secretary.

The minutes of the last meeting were read and approved.

A letter was read from Colonel S. H. Long, Bureau of Topographical Engineers, War Department.

Donations to the Library were received from the Royal Society, the Royal Geographical Society, the Royal Astronomical Society, and the Institute of Actuaries, London; the Bureau Topographical Engineers, War Department, Washington, D. C.; John Wiley, Esq., and Jordan L. Mott, Esq., City of New York; the Mechanics Association of Worcester County, Mass.;George R. Smith, Esq., Senate of Pennsylvania, and the Pennsylvania Legislature, Harrisburg; Prof. John F. Frazer, Philadelphia.

The Periodicals received in exchange for the Journal of the Institute, were laid on the table.

The Treasurer read his statement of the receipts and payments for the month of December, and his annual statement for 1861.

The annual report of the Committee on Publications, of the state of the Journal for 1861, was read.

The Board of Managers and Standing Committees reported their minutes.

Candidates for membership in the Institute (10) were proposed, and the candidates proposed at the last meeting (9) were duly elected.

The Tellers of the Annual Election for Officers, Managers, and Auditors for the ensuing year, reported the result, when the President declared the following gentlemen duly elected:—

John C. Cresson, President.

John Agnew, Matthias W. Baldwin, } Vice Presidents.

Isaac B. Garrigues, Recording Secretary.

Frederick Fraley, Corresponding Secretary.

John F. Frazer, Treasurer.

MANAGERS.

Samuel V. Merrick,	Thomas J. Weygandt,	John E. Wootten,
Thomas Fletcher,	George Erety,	Joseph Hutchinson,
Edwin Greble	Evans Rogers,	William A. Drown,
Thomas S. Stewart,	Robert Cornelius,	Ferdinand J. Dreer,
Alan Wood,	James H. Bryson,	B. Franklin Palmer,
John E. Addicks,	John M. Gries,	Coleman Sellers,
Isaac S. Williams,	Washington Jones,	William Weightman,
George W. Conarroe.	William Harris,	James S. Whitney.

AUDITORS.

Samuel Mason, James H. Cresson,
William Biddle.

At a meeting of the Board of Managers, held January 22d, 1862, the following officers were elected for the ensuing year:

Washington Jones, Chairman.

Isaac S. Williams, William A. Drown, } Curators.

Mr. Howson, of the Committee on Meetings, exhibited an improved Cannon-sight; also, a Telescope for measuring distances, both invented by Mr. Altemus, of this city.

The main advantages of the cannon-sight are its self-adjustability to the surface of the cannon, and the facilities which it affords to the gunner for taking a rapid and accurate aim; the telescope is provided with a glass disc, so graduated by means of a diamond, that the distance of any object, the height of which is known, can be readily ascertained. The lines made by the diamond on the glass disc take the place of the spider's web heretefore used, and cannot be displaced.

Mr. Howson also exhibited a pair of Manacles, patented by A. Rankin, Esq., of this city. The difference between the new manacles and those in common use, was explained by the exhibitor, who showed that the common manacles could be unlocked by striking them in a peculiar manner against any hard substance.

A Pocket-Album for Photographs, the invention of Mr. Altemus, of this city, was exhibited. The leaves holding the photographs are so hinged to each other, and to the binding, that a number of pictures may be shown and compared at the same time.

Mr. Howson also exhibited a Graduated Glass Measure invented by W. Hodgson, Jr., the graduations of which are formed during the operation of moulding.

Also, a Self-priming Pistol, invented by Mr. Butterfield, being a revolver with a self-priming lock. This has been approved of by the military authorities, who have ordered a large number.

Also, Mr. Andrews' Tobacco-pipe. This has two chambers, separated by a grating on which the tobacco rests, the lower chamber serving as a reservoir for the nicotus, the upper chamber being detachable.

Also, a Portable Writing Case invented by Mr. W. T. Fry; this contains a very complete supply of such articles of stationery as may be needed in traveling and is well adapted for army use.

METEOROLOGY.

For the Journal of the Franklin Institute.

The Meteorology of Philadelphia. By JAMES A. KIRKPATRICK, A.M.

DECEMBER.—The month of December, 1861, was warmer than usual, the temperature being 4½° above that of December, 1860, and about 1¾° above the average temperature of the month for eleven years.

The warmest day of the month was the 9th, of which the mean temperature was 54·2°. The weather from the 4th to the 9th was warm and hazy, resembling the Indian Summer. The highest temperature for the month (64°) occurred on the 10th.

The coldest day was the 28th, with a mean temperature of 26½°. The register thermometer indicated the lowest (19°) on two days, the 4th and the 26th.

The range of temperature for the month was, consequently, 45°.

The temperature was below the freezing point on 21 days of the month, though it rose above that point in the course of the afternoon of every day except the 25th.

No interruption whatever to navigation was caused by ice in either the Delaware or Schuylkill rivers during the month.

The greatest change of temperature in the course of a day was 23° on the 10th; the least was 6° on the 24th. The average daily oscillation of temperature for the month (14·58°) was nearly 2½° greater than the average for eleven years.

The greatest mean daily range of temperature was 15·7°, and occurred between the 10th and 11th days of the month; the least was 1·3°, between the 6th and 7th. The average daily range for the month (5·66°) was about three-fourths of a degree less than the average for eleven years, and about two-thirds of a degree more than the range for December, 1860.

TABLE I.—*A General Abstract of the Meteorological Observations made at Philadelphia during the year* 1861.

Latitude, 39° 57½′ N. Longitude, 75° 10½′ W. from Greenwich. Height of Barometer fount, fifty feet above mean tide in the Delaware River.

1861. Months.	Thermometer.									Barometer, reduced to 32° F.								Dew Point.			
	Maximum.	Minimum.	Range. Monthly.	Range. Mean daily.	Mean daily oscillation.	Means. 7 A. M.	Means. 2 P. M.	Means. 9 P. M.	Means. Average.	Highest.	Lowest.	Range. Monthly.	Range. Mean daily.	Means. 7 A. M.	Means. 2 P. M.	Means. 9 P. M.	Means. Average.	Means. 7 A. M.	Means. 2 P. M.	Means. 9 P. M.	Means. Average.
	°	°	°	°	°	°	°	°	°	Inch.	Inch.	Inch.	Inch	Inch.	Inch.	Inch.	Inch.	°	°	°	°
January,	49½	1	48½	5·98	11·61	27·67	34·34	30·90	30·97	30·526	29·460	1·066	·229	29·991	29·953	29·968	29·971	22·43	25·73	25·59	24·58
February,	68½	—1	69½	8·90	17·27	33·86	45·55	39·14	39·52	30·485	29·308	1·177	·264	29·954	29·912	29·951	29·939	26·56	27·89	29·67	28·04
March,	78½	16	62½	8·66	18·18	37·73	48·71	41·58	42·67	30·286	29·354	1·032	231	29·917	29·862	29·906	29·895	28·41	28·65	30·58	29·21
April,	88	33	55	5·85	19·05	47·18	60·55	51·10	52·91	30·233	29·213	1·020	·143	29·845	29·787	29·816	29·816	36·44	35·68	39·45	37·19
May,	83	36	47	5·06	19·55	55·40	65·74	57·00	59·38	30·132	29·096	1·036	·156	29·744	29·691	29·726	29·720	42·15	41·78	43·47	42·47
June,	91	51	40	5·29	18·55	69·30	79·27	70·83	73·13	30·062	29·528	·534	·104	29·783	29·742	29·739	29·754	56·69	58·75	60·04	58·49
July,	95	55	40	3·70	19·29	72·74	82·87	72·69	76·10	29·961	29·505	·456	·078	29·800	29·765	29·780	29·781	62·56	60·36	62·62	61·85
August,	94	54½	39½	3·94	16·81	68·88	79·52	71·05	73·15	30·212	29·608	·604	·098	29·912	29·896	29·910	29·906	63·60	63·77	64·20	63·86
September,	86	46	40	4·41	17·22	62·37	74·75	66·72	67·95	30·343	29·283	1·060	144	29·953	29·913	29·924	29·930	56·94	59·15	59·90	58·66
October,	88	31	54	5·28	16·94	54·32	66·61	58·69	59·87	30·452	29·469	·983	166	29·945	29·893	29·926	29·921	48·65	51·43	51·07	50·38
November,	63½	29	34½	4·11	13·08	39·85	48·73	43·25	43·94	30·109	29·213	·896	·179	29·793	29·736	29·785	29·771	33·48	33·90	34·04	33·81
December,	64	19	45	5·66	14·58	32·52	42·26	35·88	36·88	30·462	29·292	1·170	213	30·040	29·992	30·012	30·015	26·90	29·49	29·80	28·73
Annual means,	95	—1	96	5·57	16·85	50·15	60·74	53·21	54·71	30·526	29·096	1·430	167	29·890	29·845	29·870	29·868	42·07	43·05	44·20	43·11
Winter,	68½	—1	69½	6·63	13·69	30·28	38·51	33·95	34·25	30·526	29·285	1·241	230	29·961	29·925	29·959	29·949	24·22	26·20	26·42	25·61
Spring,	88	16	72	6·52	18·93	46·77	58·33	49·89	51·66	30·386	29·096	1·290	·177	29·835	29·780	29·816	29·810	35·67	35·37	37·83	36·29
Summer,	95	51	44	4·31	18·23	70·31	80·55	71·52	74·13	30·212	29·505	·707	093	29·832	29·801	29·810	29·814	60·95	60·96	62·29	61·40
Autumn,	88	29	59	4·60	15·75	52·18	63·36	56·22	57·25	30·452	29·213	1·239	·163	29·897	29·847	29·878	29·874	46·36	48·16	48·34	47·62
Means for 10 years,	100½	—5½	106	5·61	15·19	49·74	60·05	53·20	54·33	30·704	28·884	1·820	155	29·892	29·853	29·877	29·874		43·67		

TABLE I (*Continued*).—*A General Abstract of the Meteorological Observations made at Philadelphia during the year* 1861.

TABLE I (*Continued*).—*A General Abstract of the Meteorological Observations made at Philadelphia during the year* 1861.

1861. MONTHS.	Relative Humidity.							Force of Vapor.							Clouds, Sky covered.				Rain, or melted snow.		Winds.	
	Maximum.	Minimum.	Range.	Means.				Maximum.	Minimum.	Range.	Means.				Means.				Amount.	No. of days it fell.	Monthly resultant.	No. of times in 1000
				7 A. M.	2 P. M.	9 P. M.	Average				7 A. M.	2 P. M.	9 P. M.	Average	7 A. M.	2 P. M.	9 P. M.	Aver'g.				
	Pr ct.	Pr ct.	Pr ct.	Per ct.	Per ct.	Per ct.	Per ct.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.					Inch.		Direction.	
January,	100	40	60	80·4	71·8	80·7	77·7	·244	·034	·210	·128	·144	·145	·139	·69	·65	·47	·60	4·620	13	N 52° 12′ W	375
February,	100	25	75	75·0	52·5	69·7	65·7	·375	·023	·352	·158	·169	·186	·171	·54	·66	·55	·58	2·124	9	S 77 6 W	354
March,	95	21	74	69·3	47·9	65·7	61·0	·479	·051	·428	·175	·182	·185	·181	·61	·61	·48	·57	3·903	9	N 73 37 W	328
April,	95	22	73	66·9	42·3	65·3	58·2	·520	·109	·411	·231	·226	·259	·238	·50	·61	·47	·53	4·150	9	N 73 30 W	177
May,	100	18	82	62·7	44·5	62·6	56·6	·594	·069	·525	·282	·284	·297	·288	·42	·55	·39	·45	6·240	13	N 72 48 W	257
June,	94	19	75	66·2	51·9	69·7	62·6	·813	·142	·671	·475	·512	·530	·505	·61	·61	·39	·54	4·485	15	S 81 52 W	176
July,	97	32	65	71·2	47·7	72·2	63·7	·819	·284	·535	·578	·540	·579	·567	·52	·61	·59	·57	2·826	14	S 58 43 W	368
August,	92	34	58	83·4	60·3	79·3	74·3	·841	·296	·545	·602	·608	·612	·607	·70	·64	·50	·61	2·864	12	S 85 55 E	88
September,	97	42	55	82·8	59·8	79·0	73·8	·770	·279	·491	·476	·516	·532	·508	·64	·61	·38	·54	4·976	6	S 75 28 W	181
October,	97	33	64	81·4	59·7	76·5	72·5	·731	·122	·609	·373	·415	·410	·399	·70	·61	·48	·60	3·597	10	N 75 10 W	211
November,	96	32	64	78·2	58·1	70·5	68·9	·523	·099	·424	·199	·210	·206	·205	·52	·67	·52	·57	4·613	11	N 68 12 W	324
December,	95	23	72	79·5	61·9	78·5	73·3	·390	·069	·321	·155	·175	·173	·168	·60	·56	·33	·50	2·016	4	N 74 3 W	383
Annual means,	100	18	82	74·8	54·9	72·5	67·4	·841	·023	·818	·319	·332	·343	·331	·59	·62	·46	·55	46·414	125	N 81 41 W	239
Winter,	100	25	75	78·1	63·4	74·4	72·0	·375	·023	·352	·139	·151	·155	·148	·62	·67	·50	·60	10·045	30	N 65 37 W	354
Spring,	100	18	82	66·3	44·9	64·5	58·6	·594	·051	·493	·229	·231	·247	·236	·51	·59	·44	·51	14·293	31	N 73 18 W	254
Summer,	97	19	78	73·6	53·3	73·7	66·9	·841	·142	·699	·552	·553	·574	·560	·61	·62	·49	·57	10·175	41	S 61 23 W	156
Autumn,	97	32	65	80·8	59·2	75·3	71·8	·770	·099	·671	·349	·380	·383	·371	·62	·63	·46	·57	13·186	27	N 76 25 W	204
Means for 10 years,	100	13	87	76·2	57·6	72·5	68·8	1·059	·013	1·046	·326	·343	·347	·339	·59	·60	·44	·54	44·864	126	N 75° 37′ W	217

TABLE II.—*A Comparison of some of the Meteorological Phenomena of* DECEMBER, 1861, *with those of* DECEMBER, 1860, *and of the same month for* ELEVEN *years, at Philadelphia, Pa.* Latitude 39° 57½′ N.; longitude 75° 10½′ W. from Greenwich.

	Dec. 1861.	Dec. 1860.	Dec. 11 years.
Thermometer.—Highest,	64°	50°	71°
" Lowest,	19	13·5	5
" Daily oscillation,	14·58	12·2	12·23
" Mean daily range,	5·66	5·0	6·36
" Means at 7 A. M.,	32·52	29·32	31·73
" " 2 P. M.,	42·26	35·65	39·21
" " 9 P. M.,	35·88	31·82	34·57
" " for the month,	36·88	32·26	35·17
Barometer.—Highest,	30·462 in.	30·418 in	30·678 in.
" Lowest,	29·292	29·285	28·946
" Mean daily range,	·213	·196	·212
" Means at 7 A. M.,	30·040	29·937	29·961
" " 2 P. M.,	29·992	29·911	29·923
" " 9 P. M.,	30·012	29·958	29·945
" " for the month,	30·015	29·936	29·943
Force of Vapor.—Means at 7 A. M.,	·155 in.	·132 in.	·142 in.
" " " 2 P. M.,	·175	·140	·169
" " " 9 P. M.,	·173	·134	·155
" " " for the month,	·168	·135	·155
Relative Humidity.—Means at 7 A. M.,	79·5 per ct.	78·9 per ct.	77·3 per ct.
" " " 2 P. M.,	61·9	65·8	66·2
" " " 9 P. M.,	78·5	72·7	75·6
" " " for the month,	73.3	72·5	73·0
Rain and melted snow, amount	2·016 in.	3·301 in.	3·707 in.
No. of days on which rain or snow fell,	4·	8	10·1
Prevailing winds—Times in 1000-ths,	s74°3′w. ·383	s51°45′w ·411	s56°43′w ·291

The pressure of the atmosphere was greatest on the morning of the 13th, when the mercury stood at 30·462 inches; but the average pressure for the day was greatest on the 12th, the mean for that day being 30·413 inches, while for the 13th it was but 30·360 inches. The atmospheric pressure was least on the 23d of the month, falling as low as 29·292 inches, during the prevalence of a heavy continuous rain. The average pressure for the day was 29·411 inches. The monthly range of pressure was 1·170 inches. The average pressure for the month (30·015 inches) was greater than for any December since 1851; it was 0·076 in. greater than in December, 1860, and 0·072 in. above the average for eleven years.

The greatest mean daily range of atmospheric pressure was 0·768 of an inch, between the 22d and 23d days of the month; the least was 0·006 of an inch, between the 9th and 10th; and the average mean daily range for the whole month was 0·213 of an inch, which is almost identical with the average range for the whole period of observation.

The force of vapor and dew-point were greater than usual. The force of vapor was greatest (0·390 in.) on the 9th, and least (0·069 in.) on the 15th of the month. The average for the month was above the general average.

The relative humidity was greatest (95 per cent.) during fogs on

the mornings of three days, viz: the 7th, 18th, and 23d, and least (23 per cent.) on the afternoon of the 15th of the month. The average for the month was very near the general average.

Rain or snow fell on but four days of the month, viz: on the 11th, the 22d, and 23d, and early on the morning of the 27th; the aggregate depth being only 2·016 inches, of which more than three-fourths fell from 9 P. M. on the 22d, to 7 P. M. on the 23d. The number of rainy days was less than ever before observed for the month of December, and the amount of rain and melted snow was less than for any other December since the year 1851, when less than two inches fell. The average number of rainy days for December is 10, and the average amount of rain and melted snow for the month in a period of eleven years is 3·707 inches.

There were but two days of the month, the 5th and the 13th, entirely clear or free from clouds at the hours of observation; and the sky was completely covered with clouds at those hours on but two days, the 1st and 22d of the month. The average amount of the sky covered with clouds during the month of December, 1861, was about 50 per cent.; during December, 1860, it was 60 per cent., and the average amount for eleven years is a little over 58 per cent. of the visible sky.

The Year 1861.—The year 1861 was warmer than usual. It was about six-tenths of a degree warmer than 1860, and nearly four-tenths of a degree warmer than the average temperature for the last ten years.

The maximum temperature (95°) occurred on the 8th of July; the minimum temperature (— 1°) one degree below zero, on the 8th of February.

The warmest day of the year was the 8th of July, of which the mean temperature was 87·8°. The coldest day was the 13th of January, the mean for that day being 7·8°.

Of the seasons, the Winter was nearly one degree (·96) warmer, and the Summer more than one and a quarter degrees (1·27) colder than the average for ten years. The Autumn was half a degree warmer than usual, while the Spring was very close to the average temperature for the whole period of observation.

All of the months, with the exception of three, were within two degrees of their average temperature. The greatest variation was in February, which was (5·7°) more than five and a half degrees warmer than usual. It was the warmest February for ten years, with the exception of February, 1857, which was half a degree warmer. The month of October was more than three degrees (3·16°) above the average temperature of that month, and was the warmest October during the whole period of observation. May was about three and a half degrees (3·52°) below its average temperature, and was the coldest May for ten years, with the single exception of May, 1858, which was seven-hundredths of a degree colder. The average temperature of each month is exhibited in Table I.

The maximum pressure of the atmosphere (30·526 in.) occurred on